Information acumen

Comparative and International Business Series: Modern Histories
Edited by Geoffrey Jones and Mira Wilkins

Banks as Multinationals
Edited by Geoffrey Jones

Industrial Training and Technological Innovation
Edited by Howard F. Gospel

The Rise and Fall of Mass Marketing
Edited by Richard Tedlow and Geoffrey Jones

The Precision Makers
Mari Williams

Information acumen

The understanding and use of knowledge in modern business

Edited by Lisa Bud-Frierman

ROUTLEDGE

London and New York

First published 1994
by Routledge
11 New Fetter Lane, London EC4P 4EE

Simultaneously published in the USA and Canada
by Routledge
29 West 35th Street, New York, NY 10001

Typeset in Times by J&L Composition Ltd, Filey, North Yorkshire

Printed and bound in Great Britain by Biddles Ltd, Guildford and King's Lynn

British Library Cataloguing in Publication Data
A catalogue for this book is available from the British Library.

Library of Congress Cataloging in Publication Data
Information acumen: the understanding and use of knowledge in modern business/edited by Lisa Bud-Frierman.
p. cm. – (Comparative and international business. Modern histories series)
Papers selected and revised from a meeting entitled 'Global Perspectives on Business Information', held at the Department of Economics, University of Reading, in April 1992.
Includes bibliographical references and index.
1. Business information services – Congresses. 2. Management-Information services – Congresses. 3. Business information services – Utilization – Congresses. 4. Information technology – Congresses. I. Bud-Frierman, Lisa, 1952– II. Series.
HF54.5.I565 1993
658.4′038 – dc20 93–10558

ISBN–0–415–07788–5

Contents

Figures and tables

FIGURES

TABLES

Contributors

Geoffrey Bowker is Visiting Scholar at the Graduate School of Library and Information Science, University of Illinois, Champaign-Urbana (USA).

Lisa Bud-Frierman is Research Fellow at the Department of Economics, University of Reading (UK).

Martin Campbell-Kelly is Senior Lecturer at the Department of Computer Science, University of Warwick (UK).

Mark Casson is Professor and Head of the Department of Economics, University of Reading (UK).

Alain Desrosières is Research Fellow at the Département de la Recherche, République Française Institut National de la Statistique et des Etudes Economiques, Paris (France).

Richard R. John is Assistant Professor at the Department of History, University of Illinois, Chicago (USA).

Pierre-E. Mounier-Kuhn is Research Fellow at the CNRS and Centre de Recherches sur l'Histoire de l'Europe Moderne, Paris IV Sorbonne, Paris (France).

Theodore M. Porter is Associate Professor at the Department of History, University of California, Los Angeles (USA).

Susan Leigh Star is Associate Professor at the Department of Sociology, University of Illinois, Champaign-Urbana (USA).

Kaoru Sugihara is Senior Lecturer at the Department of History, School of Oriental and African Studies, University of London (UK).

JoAnne Yates is Associate Professor of Management Communication at the Sloan School of Management, Massachusetts Institute of Technology (USA).

BK Titles

IX – X

Preface

NA

The history of modern business information hardly exists, being as it is a new field crossing many disciplinary boundaries. The meeting entitled 'Global Perspectives on Business Information' held at the Department of Economics, University of Reading in April 1992 brought together scholars from a variety of communities. A number of papers given at the conference were selected and revised for inclusion in this volume. My deepest thanks to all who attended for their lively participation. As one of a series of multidisciplinary conferences organized by the Reading Business History Group, on topics ranging from multinational banking to mass marketing and business cultures, I was able to rely on the wealth of knowledge already contained in the Department. It was a truly corporate pursuit.

Arranging an international workshop was primarily an exhilarating activity, interspersed with the occasional daunting moment. My colleagues shared both aspects with me. I am particularly indebted to Geoffrey Jones, a veteran conference organizer, for his enduring enthusiasm and wise counsel. I should like to express my gratitude to the Department of Economics for its generous financial and moral support which helped launch and sustain this project. The encouragement of Mark Casson, departmental head, has been especially appreciated. It was only possible to orchestrate every detail of the conference with the calm and unfailing assistance and information-management skills of Lynn Cornell. She has also worked hard to prepare parts of the manuscript for publication.

Academic communities may form, but do not usually thrive, without face-to-face encounters. This is particularly so in the case of scholars interested in business information, who come from heterogeneous disciplines and are geographically dispersed. These factors did not prove to be an impediment thanks to the magnanimity of our

sponsors. The British Council provided three travel grants to foreign participants. A British Academy grant assisted another visitor from abroad with travel and accommodation costs. Last but not least, a grant from the Nuffield Foundation helped cover accommodation and meal expenses for both UK and other conferees.

Several individuals from outside the Department also gave me useful advice. I am indebted to Bruno Latour, Sharon MacDonald, Everett Mendelsohn and Richard Tedlow for suggesting participants. For help in editing the volume I am also indebted to Martin Campbell-Kelly, to Lucy Isenberg and to my husband Robert Bud. Hiromi Yamamoto helped check Japanese bibliographic references. Thanks as well to my editors at Routledge, Diana Grivas, Laura Large, Michael Leiser, Marguerite Nesling and Rosemary Nixon. Finally, I would like to thank my son, Alex, who reminds me that kite-flying is even more important than producing books.

1-3

BK Titles ?

Introduction

Lisa Bud-Frierman

DF3 LV6

'Information technology' and the 'information society' have been the subject of many works in recent years, both popular and academic (Beniger 1986: 4–5).[1] Whether positive or sceptical, their authors betray a collective zeal which has tended to obscure the origins of such phenomena. Yet there were precedents for many of the current changes and our ideas about them. Over the past decade a handful of scholars have concentrated on the development of business information, most notably James R. Beniger (1986), JoAnne Yates (1989) and those contributing to Peter Temin's (1991) edited book. Their pathbreaking studies all focus on the United States and originate in the disciplinary contexts of management and communications studies, economics, and business and economic history.

This volume differs from such recent treatments in two respects. First, it takes an international comparative approach which reflects the growth of modern business on a worldwide basis. Second, it encompasses the academic fields already mentioned, enriched by the perspectives of sociology, statistics, and history of science and technology. Though the approaches, methodology and language are consequently diverse, key concerns are shared and this volume therefore highlights common issues.

The volume is structured in three parts. First, 'Historical context' is concerned with the growth of business information at critical stages in the development of economies. Since the modern firm has its roots late in the last century, the emphasis is primarily on the period since then.[2] Yates and Campbell-Kelly are looking at the inside of companies, during the American Gilded Age and in Victorian Britain, respectively, while Sugihara and John are examining the role of information in the business environment, the former in Meiji Japan and the latter in nineteenth- and twentieth-century America.

Chapters in the second section, 'Business context', concentrate on economic and sociological features of business information. Contemporary issues are dealt with, by each author, on a comparative basis, Mounier-Kuhn analyses French information technology companies within an international market. Casson studies the economics of information flow within firms and markets. Desrosières investigates the relationship between official government statistics and business. Finally, Bowker and Star describe the sociological dimension of information in international organizations.

Because knowledge itself has long been the concern of historians of science, the concluding section, 'Knowledge and business' draws upon their expertise. Porter elucidates the common nature of information within business, bureaucracy and science. Finally, Bowker explores the process through which information has become both an economic commodity and fact about the world.

NOTES

1 Beniger identifies key discussions of the information society since 1950 in his chronology of modern societal transformations.

2 The proliferation of mercantile information and commercial intelligence was already well under way in the international trading arena prior to the advent of the modern form. For example see Chapman (1992), Cohen (1982), Jones (1987), Levenstein (1991) and Bud-Frierman (forthcoming). Information-gathering techniques and practices developed then were sometimes incorporated into later systems used by modern industrial firms and governmental agencies.

BIBLIOGRAPHY

Beniger, J. R. (1986) *The Control Revolution: Technological and Economic Origins of the Information Society*, Cambridge, MA: Harvard University Press.

Bud-Frierman, L. (forthcoming) 'Constructed and real: a history of agricultural statistics in nineteenth-century Britain', unpublished Ph.D. dissertation, University of Pennsylvania.

Chapman, S. (1992) *Merchant Enterprise in Britain from the Industrial Revolution to World War I*, Cambridge: Cambridge University Press.

Cohen, P. C. (1982) *A Calculating People: The Spread of Numeracy in Early America*, Chicago: University of Chicago Press.

Jones, C. A. (1987) *International Business in the Nineteenth Century: The Rise and Fall of a Cosmopolitan Bourgeoisie*, Brighton: Harvester.

Levenstein, M. (1991) 'The use of cost measures: the Dow Chemical Company, 1890–1914', in P. Temin (ed.), *Inside the Business Enterprise: Historical Perspectives on the Use of Information*, Chicago: University of Chicago Press.

Temin, P. (ed.) (1991) *Inside the Business Enterprise: Historical Perspectives on the Use of Information*, Chicago: University of Chicago Press.
Yates, J. (1989) *Control Through Communication: The Rise of System in American Management*, Baltimore: Johns Hopkins University Press.

4-6
N/A

Part I

Historical context

7 - 25

1 Information acumen

Lisa Bud-Frierman

D83
L86

INFORMATION INFRASTRUCTURE

The growth in size and complexity of firms has been linked by historians and economists to industrialization and the integration of world markets. Since the classic studies of Chandler and Williamson, they have come to take for granted the shift from relatively simple early nineteenth-century localized, single-product firms to large twentieth-century vertically integrated enterprises producing many products for an international market (Chandler, 1962, 1977, 1990; Williamson 1975). This analysis has been extended and deepened by recent work on the evolution of information systems within American firms during the transitional period (Johnson 1991; Levenstein 1991). In these accounts particular stress has been laid on the function of knowledge, monitoring (personnel and operations) and management strategies. A complementary theme emerges in this volume – the generation and interpretation of information within firms. Analogous questions about the production, meaning and management of business information arise too at the national and market levels of aggregation. The approach here acknowledges both parts of this duality.

A challenge to the notion of *an* information society is latent in many of the essays. The comparative and relativist approach taken here would suggest that the concept of 'information societies' would be a more accurate description. But even this latter term is too much of an agglomeration to be of much analytic utility. The concept of 'information infrastructure' is a more useful unit of discourse, being both a unique historical and cultural entity as well as comparable at the appropriate level of aggregation.

Information infrastructure is a key concept, which has generally been applied in two senses here. At the *micro*-level the authors have analysed the information structure of organizations and systems,

primarily within firms, although other large enterprises, including scientific networks and governmental agencies, have been included for comparative purposes. At the *macro*-level they have focused on the underlying foundation of information in society or the fixed information capital within an economy. Though these two aspects are distinct, they intermingle in the various accounts. This is not simply an artefact of whether the emphasis is on factors internal or external to firms; it is a reflection of a real ambiguity. Take for example, multinational enterprises, which inhabit different environments simultaneously, operating within contrasting socio-cultural and economic milieux. In such cases the national and international communications structures outside the firm are as essential as information technology within a firm. A coherent and comprehensive picture would encompass both the micro- and macro-levels. It is the purpose of this volume to explore, develop and sharpen the conceptual tools required to achieve this aim.

BEFORE COMPUTERS

Visions of the role of information in the economy are themselves taken here as an historical product. John, in his historiographic piece on the American concept of the communications revolution, asks why a quasi-millennial tone has permeated communications technology scholarship for over 50 years. He points to a long tradition, already evident in the early nineteenth century, which links technological developments (e.g. printing, the postal system, and later telegraph, telephone, computers, etc.) with the progress of civilization.

In the United States the discipline of business history was profoundly affected by the work of economic historian Robert Albion, who argued in the 1930s that 'space-destroying' technology, and especially speed, was the single most important factor in transforming America's industrial economy since the eighteenth century. Albion's concept of the 'communication revolution' influenced the thinking of leading business historians, including Alfred D. Chandler, Jr and Thomas Cochran (1974). Both accept Albion's stress on the spatial element and economies of speed. Chandler believes the significant changes did not occur until the nineteenth century but argues, like Albion, that discrete technological innovations were of the utmost importance. For him the changes initiated by the steam railroad and electric telegraph, based on new sources of energy, were what paved the way for the movement of commercial and industrial information. Cochran does not subscribe to this preoccupation of Albion and

Chandler with technological innovation. Though Cochran accepts Albion's periodization, he argues that the 'business revolution' was based primarily on a social structure that encouraged the expeditious processing of business information and a cultural environment that facilitated entrepreneurship.

John then discusses the contribution of sociologist Daniel Bell, who has written about the 'information society' as a twentieth-century phenomenon based on modern communications technology and the social transformation from a labour- to a knowledge-based economy. Bell's concept of a 'communications infrastructure' is not just a discrete technological development or attribute. It is a complex arrangement of interrelated parts that follows its own internal logic and that aids the processing of information as well as its movement over space. For Bell the information infrastructure plays an autonomous role as an agent of change in the economy.

Finally, John describes the work of James Carey, cultural critic, who believes that technology has been falsely invested with meaning. In fact, according to him, public policy was the decisive factor in establishing the communications infrastructure. Soon after the US Constitution was completed, policy-makers decided to encourage the rapid and inexpensive movement of information across the country. It was a political decision first and foremost, not a technological innovation, which made the United States an information society in the late eighteenth century. Human agency is therefore much more prominent in Carey's account than in Chandler's or Cochran's. Carey believes the transmission of information, as a commodity, over long distances, has been at the expense of shared community values.

Bowker also explores how the mundane and sublime often coalesce in accounts of the 'information revolution'. He, like John, places the origins of current thinking in this vein firmly in the nineteenth century. Bowker reviews the work of modern historians and philosophers of science which explain how scientific classification systems reflected changing views of space and time since the Industrial Revolution. He reflects on the philosophy of Charles Babbage, the nineteenth-century English mathematician, whose work foreshadowed modern computing and extended to the British postal system. In his narrative analysis of Babbage's ideas about information and the natural universe, Bowker shows that the socio-economic framework and organization of time and space, both transformed by technological change, were inscribed into Babbage's descriptions of the cosmos.

Beyond visionary rhetoric and information mythology is the more

worldly question of the response of historic infrastructures to novel challenges, especially in the form of new techniques and technologies. Many of the studies in this volume show how pre-existing organizational structures vary in their capacity to adapt to change; some lend themselves to innovation, while others are less flexible and more resistant. A distinction can be made between *embedment* and *entrenchment*. An embedded information infrastructure may be long standing, firmly and deeply fixed, yet this implies nothing about whether it can or cannot facilitate development. An entrenched system is also securely established, but its management and organizational structures are defensively arranged to ward off change, either from within or without.[1]

The uptake of new technology has sometimes, if not always, been facilitated by earlier paper-based systems.[2] Yates has emphasized elsewhere that existing genres of internal communication, such as printed forms or memos can support a new medium. Duplicating technology, for instance, reduced the cost and increased the use of many genres of communication within firms. (Yates 1989: 65–6.) There is no doubt that new techniques and technologies can be integrated into old structures, even when conflicting elements are present within firms. Equally, certain structural factors or an organizational reluctance can thwart mechanization and the assimilation of innovative practices. Johnson (1991: 42) has discussed the general problem of how businesses with 'inappropriate information systems' can 'survive and prosper for years'. This may happen, he argues, in situations where there is a certain degree of uniformity within a country, and may persist until international competition brings these systems into disrepute.

The quite different pressures for continuity and change within British and American firms are treated in this volume by Campbell-Kelly and Yates respectively. The Railway Clearing House, founded in 1842, was according to Campbell-Kelly, a 'pure' information business devoted to the efficient manipulation of information, achieving large economies of scale without sophisticated machinery; thus these, the first large offices in Britain were not created by office machines such as the typewriter. This was a typical example of advanced paper-based data processing in Britain at the time. Similar enormous and organizationally innovative Victorian offices developed many years before the equivalent offices in the United States, but, ironically, mechanized much later.

By the mid-1870s, the Railway Clearing House system had been perfected. It had developed into a resilient structure, which, during

its first decades, coped with rising costs, by introducing organizational reforms, such as externalizing and eliminating some of the simpler information-processing work. But having reached the leading edge, the Railway Clearing House, along with its British counterparts, began to trail behind. They were hardly touched, and certainly not transformed, by the American office-machinery revolution of the 1880s and 1890s. Fossilization occurred because investment in early office machines could only produce a marginal improvement in output. The knowledge of skilled and experienced clerks had been a brake to mechanization. Yet management attitudes, which may have been sensible at the end of the century, had become an example of complacency by the early 1900s, when the lower costs and reliability of new machines made the introduction of such technology a rational economic choice. Thus the moribund organization continued its retarded development, exacerbated by the First World War, until the 1920s when the old guard, who opposed new office machines, were confronted by a younger generation of mechanizers.

Another pre-computer age information revolution has been described by Yates. Commencing somewhat later, in late nineteenth-century America, by 1920 it had radically changed information use in business. Such new equipment as typewriters and duplicators, and new techniques, including the use of standardized forms, and graphs, became popular in this period. The basis of the revolution, however, was fundamentally different from that in Britain. In Yates' case a new systematic managerial ideology, and innovative techniques and technologies interacted in mutually reinforcing ways as a force for promoting efficiency. In Campbell-Kelly's British example there was neither an ideological engine nor technophilia. Adaptation to economic conditions consisted only of internal restructuring rather than the adoption of office machinery, a situation, Campbell-Kelly argues, which parallels the lack of innovative production technology in the manufacturing sector, with similarly dire results.

Yates explores the culture of firms in the United States. Here is a story of both the professionalization of management, and the method used for spreading an ideology within and between private companies. She concentrates on the diffusion of new information practices and strategies in two case studies.

Her analysis of Du Pont clearly shows that the adoption of new information systems was a dynamic process, which depended to a great extent on who was at the helm. She looks at the shifts in management attitudes in three generations of the Du Pont family. The late nineteenth-century head of the firm, General Henry du

Pont, opposed such changes. Francis G. du Pont, of the next generation, did not have the same disinclination and readily adopted new office technology, a common move in the 1880s and 1890s. Nevertheless he retained ineffective and unsystematic management techniques. Finally, in the third generation, his nephew, Pierre du Pont and his two cousins, introduced modern and systematic management systems in earnest when they took over in 1902. In the first and second generations, Yates argues, the symbolism of technology was very significant. The ideology of the General was opposed to newfangled devices, even though they were justified by function and cost. Francis G. du Pont, however, was keen to purchase machines because they were a symbol of the 'up-to-date' modern manager, rather than a means to gain efficiency. So the firm initially rejected changes, only heartily embracing them, many years later.

In Yates' other example, of Scovill, a brass manufacturing firm, growth was the primary factor leading to the adoption of the typewriter in 1888. It was John H. Goss, son of the company's president, who introduced modern systematic management, against much resistance in the firm during the early twentieth century. This ideology encouraged office mechanization and the establishment of reporting systems. Goss' enthusiasm, verging on the manic, led to a plethora of forms and reports, which were later revealed to be more costly than justified. This sort of overextension is due mostly to the symbolic use of technology.

The state-initiated policy in Meiji Japan to improve and coordinate the flow of commercial and technical information described by Sugihara followed a parallel path to the private systematic-management movement within American firms. Based on the belief that business information was a public good, it was implemented through state subsidies and legal changes and in a variety of genres – monthly journals, local exhibitions, advice to trade associations on how to establish training schools, conferences, publication of reports and economic statistics (consular, local government, etc.), sending business trainees overseas and reporting their findings, sending technical assistants to local industries, sponsoring commercial museums, publicity and support for commodity prize competitions. These efforts played an important part in spreading both indigenous and foreign knowledge in Japan. Thus traditional industries were revamped and innovative new businesses were established. Sugihara argues that understanding how such an information infrastructure was created is of utmost importance in formulating economic-development policy today. He notes that technological development,

for instance the installation of a physical communications system, has been ineffective in countries lacking an appropriate social structure and levels of educational attainment conducive to its use.

An important conclusion that may be drawn from these studies is that there is no monolithic information infrastructure. Rather there are a multiplicity of historic infrastructures made of many layers and couplings. These vary according to corporate culture, between industries and countries. Equally there have been, and are, many different types of information society.

AFTER COMPUTERS

In his contribution to this volume, Porter draws attention to the parallels between the spread of scientific and of business information through worldwide networks. Because of problems of space and scale the two communities have faced similar difficulties with long-distance communication. This is particularly so in the transmission of skills and knowledge, where to ensure mutual understanding, shared conventions have developed for generating and interpreting information. However, in the case of experimental science, engineering, and some industrial practices, skills are best conveyed through apprenticeships which depend on personal contact and experience. This is especially true in new, non-standardized areas, such as the building of cyclotrons in the 1930s, where visits to the Berkeley laboratory of Ernest Lawrence were essential for the acquisition of less-formalized techniques and instrument calibration. It also involves the growth of networks based on trust, which are fostered by scientific meetings, professional memberships and publication in respected journals.

All these factors came into play in the new and scientifically based, twentieth-century computer firms, which have come to epitomize 'high-tech industry' and the 'information age'. Mounier-Kuhn's study of two post-Second World War French computer companies, SEA and Bull, analyses how they kept informed about technical innovation and how their information policies shaped their respective product policies. Far from being special cases, these histories reveal the typical nature of the small new French computer enterprises, facing problems similar to other companies: evaluating the risks and costs of innovation; how to take advantage of new technology; how much to invest in R&D; the restraints of the market on strategic choices; and most significantly, how to cope with the lack of computer know-how in the public research system. Both the

macro- and micro-levels of information infrastructure came into play here.

The revolutionary invention of the stored-program computer in the late 1940s was a great challenge to companies devoted to data processing and electronics. It necessitated new investments in knowledge acquisition. R&D costs increased and so did the need for links with academic scientific researchers. From a commercial point of view, the market for computers broadened and merged. Formerly narrowly focused firms had to expand their information nets to include these new market segments (business, scientific, industrial, telecommunications). The SEA attempted to move from scientific computing into business data processing, while Bull did the reverse, trying to shift from business punched-card machinery to electronic and scientific computing.

The SEA, founded in 1948, embraced scientific research from its inception. Its founder, Raymond, an engineer, had personally visited electronics labs in the United States as early as 1946 and based the firm's long-term product policy on a momentous document obtained during the visit. The high priority given to science and technology was evident in the ready staff access to a library stocked with the latest domestic and foreign specialist publications; support for regular visits of company engineers to train in university laboratories – especially in Britain and the United States; the employment of consultants from the academic sphere; and regular attendance by representatives of the company at international conferences, and encouragement for personnel to publish in scientific and technical journals. SEA excelled in acquiring and utilizing scientific and technical information. At the same time IBM introduced its innovative 1401, SEA had produced its remarkably advanced 3900 machine. It was one of the few firms able to compete seriously against IBM's second-generation computers both technologically and in terms of price. Yet the new SEA computer was not a great commercial success because the company did not have an image in the business market and lacked the commercial networks (sales and maintenance) cultivated for decades by IBM and Bull.

In striking contrast, Bull, established in 1931, had an initial strength in the business machines market, especially banking. This orientation was reinforced by the fact that the company was directed and owned by businessmen. Between the wars, it had successfully competed in this sector, in France, against such firms as IBM and Remington Rand. None the less it was ambivalent and reactive in its science and technology policy.

In 1948, an electronics laboratory was established by Bull, in response to IBM's new products. Its founder, Leclerc and a colleague also spent a few weeks in Philadelphia at Univac with which an agreement had recently been signed; but for Bull this had been exceptional. R&D was a Cinderella division of the company. Unlike contemporary computer firms at home and abroad, Bull neither established an in-house journal for its R&D staff, nor did it systematically monitor scientific developments taking place elsewhere. Management was deeply reluctant to send engineers abroad to the United States and Britain for training, which was available in universities and at Univac. It did not even tap the resources available at French academic institutes and universities. Bull was absent from academic computer symposia and government-sponsored committees.

Mounier-Kuhn suggests that Bull fell behind in the innovation competition because of a corporate ideology based on technical self-sufficiency and an overly introverted firm culture. This was reflected for a long time in an indifference to breakthroughs in modern computing and to the potential of the scientific and military markets. It was also apparent in its policy of incremental improvements and its clinging to punched cards and plug-board programming. The internal information infrastructure was specifically flawed in monitoring, assessment and use of technological developments and scientific resources. Through the concentration of production capacity the firm achieved economies of scale and scope. It created a worldwide commercial network of subsidiaries and agencies. Compared to IBM, however, it had the disadvantage of being relatively small with an inadequate R&D budget and little government support. In Porter's terms, Bull had failed to become part of a scientific network. Like SEA, but for different reasons, Bull's position in the world market had suffered.

INFORMATION FLOW WITHIN MARKETS AND ORGANIZATIONS

Standardization

Standardization is a widespread historical trend affected by market conditions, developments in the modern firm, the state, and technological change. The significance of these factors has been noted by most contributors to this volume. Extensive and long-distance trading networks and large industrial enterprises created problems of scale

and complexity which could be partially resolved by standardization. Information costs were reduced by the spread of standard quantities and qualities both inside and outside firms. Casson and Porter have both emphasized the importance of standard weights and measures, the grading of products, and scientific classification in this regard. Casson has also discussed how information economies may result from introducing compatibility and interchangeability into communication networks. For instance, protocol standardization tends to increase information flow.

In some instances the state has intervened to establish standards. Porter relates the example of revolutionary France where the state, with the cooperation of leading scientists imposed the metric system. Even more generally since that time, bureaucratic techniques have been widely applied. In their chapters, Porter, Desrosières, Bowker and Star, all deal with the difficulties faced by governments in producing measures and categories that are commensurable over an entire nation or internationally. As Bowker and Star observe, by the twentieth century, people have become accustomed to being counted and classified and organizations have become more proficient at obtaining such information. These changes have been facilitated by new technologies of communication and computers. John, focusing on the nineteenth century, and Casson on the twentieth, have shown how such developments may have affected the speed, timeliness, reliability, storage and interpretation of large amounts of information.

One explanation of the spread of standardized business information comes under the rubric of 'local vs global knowledge'. It is a generic problem in large distributed networks and organizations. Porter has explained how similar historic conditions made information practices in business, government and science ripe for standardization, particularly in the last 200 years. He describes how the balance tipped away from local personal knowledge to global communication. Casson discusses the same process in economic terms. He argues that local custom, no longer standardized over a market area, lost much of its utility and potency. As trade became increasingly international, local sanctions tended to be replaced in contractual relations by the force of law, information-intensive monitoring, and new conventions better suited to remote communications networks.

Sugihara looks more specifically at the history of Japanese economic development. There the flow of technical and commercial information between business and government, both locally and nationally, was a critical factor in the modernization of traditional industries and expansion of foreign trade during the Meiji period.

The state actively fostered a network for the systematic collection and dispersal of information from home and abroad to meet local domestic business needs. One important aspect of this programme was the establishment of testing stations and other means for monitoring standards. This is similar to that of the grain inspectors in nineteenth-century Chicago and accountancy regulations in twentieth-century United States discussed by Porter, where local or national government pressure was applied.

An industrial economy, Desrosières suggests here, is fertile ground for the standardization of business statistics. Taking the specific case of Meiji Japan, Sugihara shows how in parallel with improving product standards to compete in foreign markets, the government raised and monitored the quality and quantity of publicly available business information. Through its foreign department (Ministry of Foreign Affairs) and domestic department (Ministry of Agriculture and Commercial Affairs) the government played an important integrating function. It compiled survey data and made it readily available through a national network of commercial museums at prefecture level and by funding technical personnel to advise local industry.

Bowker and Star argue that large international organizations inevitably face a permanent tension between universal standards and local circumstances. In their study of the World Health Organization's International Classification of Diseases (ICD) they describe the conflict within the organization as between bureaucratic aspirations to produce a standard list, and the idiosyncrasies and interests of local groups to create and use their own specific lists; a tension likened by Bowker and Star to that between R&D and marketing departments over precision. They highlight how the ICD was used by different parties as 'both a common and customizable object'. They emphasize that in a heterogeneous world the construction of standard bureaucratic forms involves compromise. Classification systems cannot eliminate ambiguity and uncertainty altogether. Rather, standard lists must be tailored to define the degree of granularity that is appropriate to the object in question.

Equally for Desrosières, the confluence of local and global interest is apparent in the history of the nomenclature of official French economic statistics. He also meets a paradox arising from the creation of a common language which describes heterogeneous business situations. It was not possible to establish equivalences and national statistics until business practices had been relatively unified. Similar problems of standardization of business classifications confront

statisticians today trying to produce comparative European business information where historical factors, social practices, and languages are different.

Negotiation

The process of negotiation within an international organization figures most prominently in the chapter by Bowker and Star. Their study of the International Classification of Diseases, a coding scheme administered by the WHO, is written from the perspective of sociology of science and technology and organizational policy. The ICD is a list of the causes of death and illness, and serves as an example of a system for gathering global information across many federated sub-organizations. Bowker and Star argue that the problems of data collection and management of the ICD are very similar to those faced by many multinational enterprises and governmental agencies. They believe that generic solutions exist for situations in which varied sources of information must be placed in compatible categories.

Bowker and Star hypothesize that decision-making processes are embedded in modern information technologies. They use the ICD as a model for discovering the nature of 'frozen negotiations' inscribed into a list. Political and cognitive compromises between a wide range of actors (doctors, epidemiologists, statisticians, government officials, anthropologists, diplomats, insurance firms, chemical firms and pharmaceutical companies) become evident. Decisions about the division of labour between those who actually make observations and those who produce the statistics with the data become apparent. They show how pragmatic solutions emerged in the negotiation process and informed policy. The ICD remains a dynamic decision-making tool which evolves with changes in practice, bureaucratic background, and technology (e.g. computerization).

The negotiated dimension of official business statistics is the focal point for Desrosières' analysis. He shows how coherent and common accounts of business activities are created by many actors and different institutions both within particular countries and internationally. Conflicts and compromises over the meanings and interpretations of concepts are an integral part of these complex operations. Desrosières offers specific examples of the pragmatic classification of business information and also discusses generic taxonomic battles between statisticians and social scientists over coding and nomenclature. He goes on to explain the economic coordinating function of the information thus produced.

Casson explores the role of negotiation within a market system, emphasizing how the recognition of the rights of other parties and the harmonization of trade-offs through the price mechanism can prevent conflict. When information costs are reduced customary prices and contracts tend to be superseded by negotiated individual agreements. In such circumstances customs may come to be used more frequently to regulate the process of negotiation itself, rather than prices. The need for an economy of language, communication and decision-making described by Casson as an important market force has some parallels with the regulation of large international projects such as the ICD described by Bowker and Star, Desrosières' official economic statistics and Porter's scientific networks. As with remote and impersonal trading negotiations, the conventions for sequencing and formatting communications were of crucial importance in all these cases.

Coordination

The problem of coordination in expanding firms has been dealt with by several authors in this volume. Yates views the new systematic ideology as, in part, a managerial response to the place and role of information in expanding firms. Information and communication were used in a novel manner to control and harmonize internal operations throughout a firm's hierarchy. The Railway Clearing House, as Campbell-Kelly has shown, was the information manifestation of a growing physical infrastructure. Conversely, the problem of effectively operating a large office was not only important in itself; this also affected the functioning of the entire railway network. Porter has described how the objective and detached information contained in American company accounts, designed to meet external standards and as a means for control, does not produce a maximally useful basis for managerial decisions. Managers must use discernment when interpreting and applying such information; otherwise their business strategies would be based on a mere delusion.

Desrosières offers a theoretical approach to the complex firm as a strategic centre of economic and financial decision within the context of a modern industrial economy. He sees the firm as a 'device of coordination' between conflicting management and economic models. Desrosières' research into statistical coding and enumeration suggests how business information is itself part of a more general mode of coordination between firms. He suggests that modes of coordination vary according to the type of firm (artisanal, mercantile,

industrial) and that different statistical approaches tend to be associated with each. He has found that industrial organizations, with their standardized practices are more amenable to statistical registration. He argues that the complex operation of objectifying business activities to create a shared knowledge is essential for giving signals for actors to coordinate their actions.

Casson discusses how price and quantity information is used for coordinating decisions both in the market and in organizations. However, the hierarchical firm may also choose to adopt different approaches to planning, based on budgetary information and monitoring; in this situation the emphasis is on value rather than on prices and quantities. The dynamic process of economic coordination is reflected in changes in the nature of information, which Casson describes.

Mounier-Kuhn identifies a serious problem of coordination at Bull, the French computer firm, in the 1950s. The maintenance of a vague hierarchical organization and a lack of direct communication between the sales and engineering staff damaged the company. This tended to encourage a limited perception of information systems which reinforced an evolutionary approach to innovation and misguided investment in tabulating machinery. Production, distribution, and resource-allocation decisions were haphazardly made and implemented. These shortcomings were also very evident in the poor quality and flow of information within the firm. Bull's management remained in the style of a small business and did not modernize to meet the needs of increased scale, and geographical and market expansion.

Bowker and Star are concerned with the infrastructural and decision-making implications of information systems in large multinational organizations. They argue that large-scale coordinated work distributed in time and space is impossible without lists. In their case study of the creation of the ICD, a complex list, Bowker and Star show how it is both a means to represent knowledge and a tool of coordination in a situation in which conflicting requirements need to be satisfactorily reconciled. Such problems of informational diversity are often faced by multinational firms having subsidiaries in several countries as well as by governments collecting economic statistics.

Costly and uncertain information

The problem of incomplete and uncertain information has been a lively and widely discussed issue in economic and organizational

studies since the Second World War (Stiglitz 1985; Raff and Temin 1991: 8). It is closely linked to the fact that information is a resource, the availability of which is limited to a large degree by cost (Stigler 1961). This means that business people must often reach conclusions about their firms based on insufficient information. The organizational implications of this uncertainty have been explored in the pioneering work of Herbert Simon and James March (Simon 1947; March and Simon 1958). Raff and Temin (1991) for example, discuss the use of regular financial and operating statistics as a form of management information designed to reduce uncertainty. Bengt R. Holmstrom, referring to the findings of sociologist, Jay Galbraith (1973), says that, 'Firms respond to uncertainty either by reducing it or adapting to it' (Holmstrom 1991: 158). Both these strategies are to be found in some of the examples which follow.

Market and social mechanisms, structural factors and technological advances all come into play as the information demands of businesses increase. Casson discusses thoroughly the many distinctive features of the market for information. Looking at the role of business information in hierarchical organizations in terms of the division of labour and resource allocation, he draws parallels between information flows within the firm and the market and distinguishes the different levels of aggregation in the description of resources that this reflects. The conclusion is that business information tends to increase as a consequence of falling information costs or rising prosperity. In addition, as the cost of uncertainty increases, firms are more willing to sustain a greater level of cost even if the utility is uncertain. Casson also explains the economic rationality behind customs and contracts developed in response to high information costs. A hypothetical example of the contractual approach to car transport raises moral and technical issues about information systems. Technological advances in speed, frequency, and reliability of information flows may at times be more significant than price in bringing down costs.

Recent studies have suggested that the firm could be more important that the market for collecting and disseminating information and for preventing uncertainties and risks (Williamson 1985). Desrosières' discussion of the construction of economic statistics based on firm and market information is a practical example of the theoretical problems involved.

Campbell-Kelly's work on the Railway Clearing House provides an historical case study of transaction costs. He demonstrates how organizational reforms, rather than technological innovations were introduced to reduce costs there. This phenomenon of restructuring

to deal with scarce business resources has recently been examined by Johnson (1991) and Raff and Temin (1991).[3]

Another important feature of transaction costs, noted by Casson, is that they often rise because it is expensive and difficult to screen out bad information . This was certainly true in the International Classification of Diseases (ICD); Bowker and Star found that costs rose with the demand for the increased accuracy of information sought by the organization. The question of quality assurance and exclusivity of information pertaining to transaction records and technological know-how arises in other circumstances too, according to Casson. The typical buyer of such information is the entrepreneur, who synthesizes it to make difficult and risky decisions. Entrepreneurs often prefer to obtain information from specialist suppliers with good reputations, who are not in a position to make competing uses of information.

Bowker presents a specific example of these technical information issues in a twentieth-century firm, Schlumberger, the French multinational. It was one of the earliest scientific and technical information companies in the world. He shows how the firm controlled data generation and interpretation in oil fields and exploited the competition between oil companies, successfully creating a niche for itself as an information broker. Schlumberger gained control of local, particular information which it was able to repackage as abstract, global scientific information. Bowker argues, as in the Babbage example, that an 'infrastructural inversion' had taken place. In other words, the organizational work practices of both Schlumberger and the oil companies left their mark on the world through their active reconfiguration of local space and time. It was within this new social space created by network technologies that Schlumberger produced and sold 'objective' information.

Certain industries are particularly information intensive. Mounier-Kuhn shows how the high level of internal investment, especially in costly information, was required in French computer firms. Money spent on technological innovation to gain a competitive advantage had to be regained through international expansion. The development of commercial and scientific networks abroad was also expensive and crucial to the companies.

Mounier-Kuhn's study shows how market strategies may go drastically off course because of incomplete knowledge. The SEA, though adept at assessing the direction of technical progress was less able to obtain and analyse market information. This may explain its difficulty in moving into the commercial sector and the decision to

merge with another company in 1967. Whereas the Achilles' heel for Bull was technical information. It suffered from chronic uncertainty due to a lack of corporate skill and knowledge about scientific developments. This weakness led to difficulties in product definition and design. By 1960 Bull was in considerable difficulty with its product line and had made strategic alliances to compete with IBM. But it based these decisions on shaky information; the company lacked knowledge about the limited innovative potential of its partners, RCA and GE, which by the 1970s were to give up manufacturing computers.

Bowker and Star argue that, rather than remaining ensconced in seeming certainty, designers and policy-makers should realize that an element of ambiguity is inherent in most 'infrastructural tools'. To underline this position they show how the ICD, a large distributed organization, gathered heterogeneous information. The diversity of actors and incompatibility of information or data structures favoured an information-management strategy based on parallel and multi-representational forms. Through its history, distributed residual categories, heterogeneous and parallel lists, and separate localized studies have been used to signal uncertainty of data collection, classification or interpretation at an appropriate level and to manage diversity through keeping control over modifications. Recently, computerization has offered the advantage of 'maintaining uncertainty at the level of closure on analysis'. More generally, Bowker and Star suggest that ambiguity may be used as an organizational resource (see also March and Olsen 1976).

CONCLUSION

Information is a resource that requires wise husbandry and an element of craft practice. This is particularly so because making knowledge involves people, whether as individuals or in social groups, and not just technology. Information skills may be located or missing in firm executives, organizational memories, in trading networks, in national leaders or in the general public.

Drawing on examples from many countries and historical settings, this volume shows how infrastructures have been built, maintained and destroyed. How those which endure may retain enough flexibility to respond to new situations or how those which ossify may succumb. Examples have been presented of entrepreneurial and organizational ability to synthesize business information and of lopsided information policies that preclude such integration.

The authors draw attention to some of the most important strategic decisions facing managers and policy-makers: choices about technological innovation, standardization, negotiation, coordination, and information costs and uncertainty. The outcome of these judgements depends on a key ingredient: information acumen. Success or failure is often determined by the presence or absence of keen insight and skill in generating, handling and interpreting information. It is hoped that this volume has pointed a way for studying these complex information processes in future.

NOTES

1 Analogous issues have been raised in the literature of organizational choice, see for instance March and Olsen (1976).
2 I am grateful to Michael Moss, Archivist, The Archives and Business Record Centre, at the University of Glasgow, for his comments about how the evolution, design and improvement of paper-based systems of business information often led to efficiency and easier retrieval.
3 Johnson (1991: 56) has suggested that in the 1920s it was less costly for large firms with diverse products to restructure than to set up costing systems. He also hypothesized that since then modern computer technology has probably made the information processing alternative a less expensive management approach than restructuring the complex firm.

BIBLIOGRAPHY

Chandler, A. D., Jr (1962) *Strategy and Structure: Chapters in the History of the Industrial Enterprise*, Cambridge, MA: MIT Press.
—— (1977) *The Visible Hand: The Managerial Revolution in American Business*, Cambridge, MA: Harvard University Press.
—— (1990) *Scale and Scope: The Dynamics of Industrial Capitalism*, Cambridge, MA: Harvard University Press.
Cochran, T. C. (1974) 'The business revolution', *American Historical Review* 79: 1499–1566.
Galbraith, J. (1973) *Designing Complex Organizations*, Reading, MA: Addison-Wesley.
Holmstrom, B. R. (1991) 'Comment' in P. Temin (ed.), *Inside the Business Enterprise: Historical Perspectives on the Use of Information*, Chicago: University of Chicago Press.
Johnson, H. T. (1991) 'Managing by remote control: recent management accounting practice in historical perspective', in P. Temin (ed.), *Inside the Business Enterprise: Historical Perspectives on the Use of Information*, Chicago: University of Chicago Press.
Levenstein, M. (1991) 'The use of cost measures: the Dow Chemical Company, 1890–1914', in P. Temin (ed.), *Inside the Business Enterprise: Historical Perspectives on the Use of Information*, Chicago: University of Chicago Press.

March, J. G. (1976) 'The technology of foolishness', in J. G. March and J. P. Olsen, *Ambiguity and Choice in Organizations*, Bergen: Universitetsforlaget.

March, J. G. and Olsen, J. P. (1976) *Ambiguity and Choice in Organizations*, Bergen: Universitetsforlaget.

March, J. G. and Simon, H. A. (1958) *Organizations*, New York: Wiley.

Raff, D. M. G. and Temin, P. (1991) 'Business history and recent economic theory: imperfect information, incentives, and the internal organization of firms', in. P. Temin (ed.), *Inside the Business Enterprise: Historical Perspectives on the Use of Information*, Chicago: University of Chicago Press.

Simon, H. A. (1947) *Administrative Behaviour: A Study of Decision-Making Processes in Administrative Organization*, New York: Macmillan.

Stigler, G. (1961) 'The economics of information', *Journal of Political Economy* 69: 213–24.

Stiglitz, J. E. (1985) 'Information and economic-analysis: a perspective', *Economic Journal* 95: 21–41.

Williamson, O. E. (1975) *Markets and Hierarchies: Analysis and Antitrust Implications*, New York: Free Press.

—— (1985) *The Economic Institutions of Capitalism: Firms, Market, Relational Contracting*, New York: Free Press.

Yates, J. (1989) *Control Through Communication: The Rise of System in American Management*, Baltimore: Johns Hopkins University Press.

26-50

2 Evolving information use in firms, 1850–1920

Ideology and information techniques and technologies[1]

JoAnne Yates

D83 L86 M10

INTRODUCTION

Today we are constantly reminded that industrial society is in the midst of a revolution in information technology and in the use of information in businesses. Often those who study the current information revolution see it as unique and unprecedented. But just a century ago American firms were in the midst of another information revolution that transformed the office and the way firms dealt with information. This information revolution introduced most of the equipment and techniques that dominated the office in the first half of the twentieth century (some of which are still with us), from telephones and typewriters to tabular forms, stencil duplicators and filing cabinets. One indicator of the magnitude of this transformation is the growth (in constant dollars) of total capital in the office equipment industry from $10 million in 1879 to $455 million in 1929 (US Bureau of Census 1960: 412). During the two decades between 1890 and 1910, capital in this industry grew at a much higher rate (194 per cent and 182 per cent) than capital in all US manufacturing (67 per cent and 81 per cent) (Beniger 1986: 398). This revolution was not, however, characterized solely by the machines it introduced; interlocking 'hardware' and 'software', technologies and techniques for handling information, helped transform information use within firms during this period.[2] Such techniques included, for example, the use of forms to aid in gathering and recording data and the use of graphical techniques for displaying information. This earlier information revolution played an important role in the emergence of the modern American firm.

This chapter will suggest that the rapid and radical transformation in information technology and techniques that supported revolutionary new business uses of information cannot be fully explained as the

purely rational economic response of individual firms to the information demands of firm growth and structural evolution, although Chandler (1977) has shown that such functional explanations are often adequate for explaining the evolution of information techniques and practices in specific, highly innovative firms. Neither can it be fully explained by changes in supply – that is, by technological determinism that views current information technology as an independent force determining its own direction of evolution and creating its own demand. While the forces of supply and demand certainly played essential roles, this paper proposes a general model (see Figure 2.1) in which a third force was also instrumental in the rapid spread of information techniques and technologies: a new managerial ideology.

Before saying anything further about the nature or role of this ideology, I must briefly clarify what I mean – and do not mean – by the value-laden term *ideology*. I am using the term neither to mean a political programme based in propaganda nor to mean the opposite of the economically rational or scientific. Rather, I follow Geertz's lead in using it to refer to a culturally embedded, symbolically expressed system of beliefs or values (Geertz 1964). Such systems of belief, he argues, provide templates for understanding and acting. They shape both the environment in which people understand situations and define options, and the decisions they make. While these systems differ from economic rationalism, their influence is not always in opposition to it; a decision made for ideological reasons can turn out to be economically rational as well.

The systematic management ideology, which had its origins in specific managerial responses to crises of coordination in growing firms, coalesced into an ideology or system of values and beliefs about the nature of management and the place of information in the managerial role. It was then widely diffused among managers and firms by publications, associations, consultants and contacts, serving as a template for managerial strategy and practice. This ideology encouraged and was encouraged by information technology and technique in a mutually reinforcing dynamic fed by motives and mechanisms including costs, symbolism and role models. While ideology was certainly not the only factor in the rapid diffusion of the new techniques and technologies within firms, it played a significant contributory role.

The first section of this chapter provides an historical narrative of the information revolution that occurred in the late nineteenth and early twentieth centuries, incorporating the emergence and role of

managerial ideology. The second section presents my model of firms' adoption of information techniques and technologies, focusing especially on the role of managerial ideology and using examples from specific firms.

THE INFORMATION REVOLUTION OF 1850–1920

Communication and information in the early and mid-nineteenth century

In the small, owner-managed firms that predominated in American business up until the mid-nineteenth century, communication and information needs were minimal and easily handled. Market prices and availability were the main sources of external information used in decision-making (Johnson and Kaplan 1987). Correspondence with suppliers, agents and customers, along with traditional account books, documented interactions with external parties. Virtually no internal, operational information was recorded or collected. Most firms had only three layers in their hierarchies: the owner/manager(s), one or more skilled artisans (who functioned as foremen or job contractors), and a few unskilled workers. Internal operations were readily managed by direct supervision and oral exchanges. The early nineteenth-century textile factories separated ownership from management and began to combine multiple functions in the same facility. At this stage, additional internal information became theoretically desirable for efficient coordination. Some of these factory owners created the first, relatively primitive cost-accounting systems for monitoring the costs and profits of their operations (Johnson and Kaplan 1987). Such information systems were still, however, rare, and other aspects of factory life, such as individual jobs and organizational procedures, were still managed primarily by word of mouth (Nelson 1974: 44).[3]

By the middle of the century, the railroads and the telegraph were allowing the expansion of local and regional markets into national markets, and in the late nineteenth century, manufacturing firms began adopting new mass-production technologies and expanding to serve the larger markets. First the transportation and communication companies themselves, and then the manufacturing firms, grew in size and organizational complexity, creating new needs for internal coordination. Beginning in the 1840s, railroad managers initiated innovations in using systematically collected internal information for coordination and control, first to assure safety and honesty and later

to address diseconomies of scale and competitive pressures. While the managerial principles articulated by leading railroad managers were harbingers of the systematic management ideology that later emerged among manufacturing managers, their direct influence was limited primarily to the railroad industry.

Systematic management and the growth of internal communication

Most manufacturing firms only began grappling with these information and communication issues in the 1880s and 1890s, as they adopted new production technologies, expanded, and encountered their own crises of coordination. Initially their growth was unaccompanied by significant changes in the *ad hoc* management methods of the past, resulting in confusion and disorder. While the hierarchy deepened, both vertical and horizontal coordination broke down (Litterer 1961b, 1963). Production itself was still generally controlled by foremen or job contractors who operated relatively autonomously (Nelson 1978). Middle and upper managers lacked tools for controlling what occurred on the production floor and for coordinating their own actions to make the horizontal flow of materials through the production process efficient. Moreover, the profits expected from expansion often failed to materialize.

In response to these problems, managers began a 'search for order and integration' that was ultimately to take form in the approach known as *systematic management* (Litterer 1961a, 1961b, 1963).[4] As innovative managers developed specific methods for dealing with the new situations they faced, some also began to formulate more general principles. Captain Henry Metcalfe, for example, was one of the earliest innovators in his managerial role at the Army Ordnance Department's Frankford Arsenal. At around 1880 he was experimenting with new systems for assuring accountability and efficiency in its operation, and by the mid-1880s he had published and presented to the American Society of Mechanical Engineers (among whose ranks many of the first discussions of systematic management principles occurred) descriptions of the system he devised and formulations of its underlying principles (Metcalfe 1885, 1886). In subsequent years, other figures such as Slater Lewis (1899) and Horace Lucian Arnold (1901) wrote about manufacturing-works management, cost accounting, and other specific systems or techniques, while Alexander Hamilton Church (1900, 1913) generalized at a higher level about the nature of management. In the early years of the twentieth century, a new managerial literature containing both

specific tactics and broader strategic formulations began to appear in periodicals such as the new *System* and the renamed *Industrial Management*, previously *Engineering Magazine*, defining and diffusing the ideology. Experts and consultants (such as A. W. Shaw, publisher of *System* and *Factory* magazines and lecturer at Harvard Business School; or William Henry Leffingwell, consultant and author on office systematizing), often referred to as systematizers, served as another mechanism for the diffusion of this set of beliefs.

The loose assemblage of methods and strategies that made up systematic management shared a common focus on efficiency as a central value or goal for businesses. Furthermore, efficiency was to be achieved through system or systematizing. Systematizing involved two general types of activities:

1 Recording and rationalizing knowledge previously only known to the individual using it, including workers' methods, managerial processes and executive knowledge. For example, one systematizer stated, 'As to the form that an order should take, the only satisfactory form is the written order . . . If the request is in writing neither [the sender nor the recipient] is obliged to depend on his memory' (Griffith 1905: 19–20). This documentary process transcended the individual and created an organizational memory for future as well as current reference.

2 Collecting and drawing operating information up the hierarchy and using it to evaluate and compare the performance of individuals and organizational units. Metcalfe (1885: 15) noted the importance of 'collecting and classifying the records of the past so that the future operations of the art may be more effective'. Church (quoted in Litterer 1961a: 223) formulated it thus: 'Under rational management the accumulation of experience and its systematic use and application, form the first fighting line.'

Managers attempted to gain control over their businesses by creating systems for every aspect of their processes and products – and to implement and monitor these systems via flows of written communication and information. In this new philosophy, management no longer meant standing over workers or foremen and managing by word of mouth; it meant control through systematic information and communication. These two principles necessitated increased documentation of all sorts. The new management periodicals were full of articles on subjects such as 'Advantage of written orders' (Burt 1910) and 'Factory purchasing system: methods and records' (Russell 1917).

Beginning in the last decade of the nineteenth century and accelerating in the early twentieth century, growing amounts of internal written communication began to flow up, down and across the firm hierarchy (Yates 1989). Systems of reports emerged to pull information up the hierarchy. Many of these reports conveyed quantitative operating measures from one level to the next, where they could be compared, analysed and consolidated with other data to proceed on up the hierarchy. As managers began to systematize procedures, they needed to communicate them downward in written form both to specify them as unambiguously as possible and to provide a source of reference on the new procedures. The written order to an individual, the circular letter or bulletin addressed to groups, and the more comprehensive and permanent rule book became important new managerial tools. Finally, horizontal flows of internal correspondence emerged to document interactions within and among different departments, even though large firms had widely adopted internal telephone systems beginning in the 1890s, enabling individuals to coordinate their actions orally if they wished.

Developing information technologies and techniques

Given the limited amount of written communication in manufacturing firms at mid-century, the supporting techniques and technologies of that era could be relatively primitive. Pen and ink were used to create and copy documents and to perform calculations. Accounts were entered (and consequently stored) in large bound volumes ruled to accommodate traditional, double-column accounts. Outgoing correspondence was copied, initially by hand and later by press copier (which used pressure and special ink to make impressions of letters), into bound volumes of blank pages. Incoming correspondence was stored in pigeonholes, box files shaped like volumes, or, later, horizontal files in cabinets.

As the volume of internal (as well as external) written communication began to increase under the influence of firm growth and systematization, it put pressure on the old methods of handling information within firms. During the period from 1880 to 1920, a variety of techniques and technologies, some new and some adapted to new uses, were introduced for recording, compiling, duplicating, storing, analysing, and presenting the increasing amount of information. In some cases, inventors or developers responded relatively directly to the business market's new information-handling needs. In others, the innovations had been intended for quite different, and

often more limited, markets but when potential business demand evidenced itself, they were adapted or marketed to it. Office equipment and methods received a great deal of publicity from systematizers writing in the management and trade press, who portrayed them as ways to improve the efficiency and reduce the cost of managing the growing quantities of information being handled by firms. Indeed, such devices and systems came to be seen as visible symbols of the modern management methods fostered by the systematic management philosophy. By the early twentieth century, these techniques and technologies, described below, were being widely adopted by manufacturing firms.

Recording and compiling

The first mass-produced typewriters appeared in 1874, aimed at a target market of court reports, authors and other specialized users. Typewriters operated by experienced typists could produce documents at three times the rate for pen and paper, thus increasing the speed and lowering the cost of producing them. Beginning in the 1880s and 1890s, firms adopted the typewriter just in time to slow the already rising costs of their increased internal and external written communication.

At about the same time, prepared forms, a bureaucratic technique previously used only occasionally within most firms, were also being widely adopted to improve the efficiency and uniformity of routinely recording and compiling standardized data. Forms were adopted by most railroads around mid-century and by many manufacturing firms at the end of the century. Such standardized forms were initially sent out to external printing shops, but later often duplicated internally. They both reduced the time spent in recording information and encouraged consistency and system in the data reported. Moreover, because the same information was always in the same place, forms made it easier to extract the data for compilation and analysis at higher levels. Such forms (as well as non-form reports) were often converted to a tabular format, eliminating figures embedded in text and thus further simplifying both the recording and the later consolidation of numerical data. Around the turn of the century, the tab function was developed for typewriters to aid the typist in typing tables and filling out forms (Leffingwell 1926).

The management journals published many articles describing forms for specific purposes (e.g. 'System for factory purchases', 1903) and proposing guidelines for making forms efficient to

use (e.g. Barnum 1925). Forms became an important symbol of system.

Duplicating

The new dependence on written rules also created a need for better methods of duplicating documents. Disseminating the increasing number of notices, policies and procedures flowing down the levels of the hierarchy required methods for duplicating documents in quantities from under ten to hundreds or even thousands. Press copying made one or possibly two copies. Multiple copies of a document could be created only by retyping or by sending it out to be printed (both slow and costly). The solution for small numbers of copies lay in carbon paper, a technology available since early in the century but only adopted for business use in conjunction with the typewriter. Before the typewriter, carbon paper could only be used with a pencil or a blunt stylus, because the steel- or gold-tipped pens of the era could not apply the requisite pressure without ruining the pen or tearing the paper (Proudfoot 1972). Thus it was not used for standard business documents. But with the typewriter, carbon paper was immediately seen to gain new usefulness. Not only could it replace the messy and slow press-copying process, but a strong typist using thin paper could make up to ten copies at a single typing. As firms adopted the typewriter in the 1880s and 1890s, they often adopted carbon paper as a way to create small numbers of copies quickly, conveniently and inexpensively.

Rapid and inexpensive methods were still needed for creating larger numbers of copies; two systems for doing so emerged in the last quarter of the century (Proudfoot 1972). The hectograph method used a gelatin bed to transfer special ink from a master document onto blank sheets of paper, making up to 100 copies. The second method, stencil copying, used a stencil master with tiny holes which allowed ink to pass through; it could make up to 1,000 copies at a time. Various devices for creating the stencil master and the copies were introduced in the United States in the late nineteenth century, starting with Thomas Edison's vibrating Electric Pen (a short-lived, relatively unsatisfactory device which left a row of pin holes as the user 'wrote' with it), introduced in 1876 for use with a manual duplicating press, and culminating with the A. B. Dick Company's Edison rotary mimeograph, introduced in the 1890s. Edison, with his market-oriented approach to invention and development (Millard 1990), recognized and targeted the potential business

market, suggesting stencil copying for internal documents such as notices and forms (Edison 1876; WEC/1883).

Storing and retrieving

The flood of new internal communication could only be used for future reference, as demanded by the new managerial ideology, when it was readily accessible. The existing storage system with its bound chronological volumes of press copies for outgoing correspondence, letter boxes or flat files (organized by subject or correspondent) for incoming correspondence, and a variety of miscellaneous systems for internal documents did not permit ready access to all documents on a specific subject. The new copying methods just discussed produced loose copies rather than bound volumes, thus making it possible to combine documents from all sources in a more comprehensive and accessible system of subject-based storage. While this recombination could have occurred (and very occasionally did) with existing equipment, it generally awaited the introduction of vertical filing to the business world at the 1893 Chicago World's Fair (Chaffee 1938).

This now-familiar method of filing combined equipment (folders, dividers and cabinets) and bureaucratic technique (a system for combining documents from all sources and organizing them by subject, location or some other indexing scheme appropriate to a firm's or individual's retrieval needs). Like forms, vertical filing systems received considerable attention in management periodicals (e.g. Wilson 1901) and in textbooks (e.g. Hudders 1916), becoming closely associated with systematic management methods. Proponents proclaimed it more efficient than the old systems both in retrieval time and in use of space. They also argued the virtues of various indexing and organizing systems, from alphabetical to decimal, agreeing only that files should be centralized. This new storage and retrieval system clearly made the increasing amounts of internal and external documentation in firms more accessible. Some evidence also suggests that such files, which quickly became decentralized in spite of expert recommendations, encouraged the generation of increased horizontal documentation.

A variant of vertical filing, the card file, was also adopted to speed retrieval of structured data such as sales or production statistics, or even a firm's central accounts (Metcalfe 1885; Morse 1900; Clark 1916; Leffingwell 1917, 1926). The cards were generally preprinted forms (usually tabular) organized by a single scheme (e.g. a customer's name or sales location). They were retrieved by this main

information category and other information could then be extracted from the cards. Card systems could also incorporate recording or analysing functions.

Analysing

In the late nineteenth and early twentieth centuries, a variety of technologies were introduced to speed the analysis of information, including both sorting and calculation. Although many technologies were initially developed for use in accounting departments (e.g. bookkeeping machines), as the systematic management philosophy encouraged the widespread use of information throughout firms, the more general devices became widely used. Card files were developed in ways that allowed more complex sorting of data. Metcalfe had pointed the way towards such use in noting the advantage of making

> each card a representative unit, capable of combination with others, according to any one or more of their common features; thereby attaining by the mechanical operation of sorting, the results otherwise achieved only by the tardy and laborious processes of book-keeping. (Metcalfe 1885: 22)

Various devices such as notches, metal tabs of different shapes or colours, and punched holes were added in designated positions to signify particular characteristics, thus enabling sorting by multiple characteristics. Beginning in the late 1880s, many office adding and calculating machines were introduced and adopted to speed numerical calculations (Leffingwell 1926; Williams 1985).

Tabulating systems combined sorting with calculating and handled much larger amounts of data than card files or calculating machines. These systems of electro-mechanical and mechanical devices sorted cards with data encoded in punched holes, then either counted cards by category or added quantities encoded on the cards. Herman Hollerith developed the first of these systems, the electro-mechanical Hollerith Tabulator, specifically to speed up processing of the 1890 Census data (Austrian 1982). When Hollerith's relationship with the Census Bureau went sour in the 1890s, he looked to large firms as potential customers. In the final years of the century, he worked with a few railroads and other firms to develop systems of machines suited to their information-processing needs. By the early decades of the twentieth century, the Hollerith and rival Powers tabulators were being widely discussed in the business and trade press (e.g. Koon 1913; Shattuck and Kapp 1926–7) and interest in and adoption of

such tabulating systems grew among large firms in a variety of industries (Austrian 1982; Norberg 1990).

Presenting

With more and more information travelling up the narrowing hierarchy, top managers could easily be inundated with information they lacked time to absorb. Although tables were efficient for gathering and consolidating statistics, they required detailed study to yield their implications. Graphs were widely adopted in the early twentieth century to make information more accessible and compelling to those using it. While graphic representations of data had existed for at least a century, they had been used primarily for government statistics and later for experimental data in science and engineering (Funkhouser 1937). Advocated by systematizers and engineers-turned-managers (e.g. Bismer 1911; Brinton 1914), graphs gained considerable popularity as a way to make the information gathered and analysed available to decision-makers in an efficient and compelling form. As with forms and vertical filing, systematizers associated graphs with 'modern' methods: 'In a modern organization the executive obtains [operating] information through a system of graphic records, a simplified summary of countless departmental statistics and itemized reports' (Parsons 1909: 214–15).

All of these changes in the collection and handling of information were fairly widely diffused even before the First World War, and the volume and efficiency demands of the war completed the transformation. The office of 1920 looked quite different from that of 1880. But the change was not simply one of different equipment adopted to perform the same information and communication functions. Both the nature of managerial information use in firms and the techniques and technologies supporting it had changed profoundly and in interaction with each other. There was not to be so significant a change in the information capabilities of the firm again until the adoption of computers and the new telecommunications technologies of recent decades.

TOWARDS A MODEL

Now I would like to step back from the changes just traced and describe and illustrate a general model (see Figure 2.1) for understanding the major forces underlying firms' adoption and use of the information techniques and technologies that so increased their information capabilities.

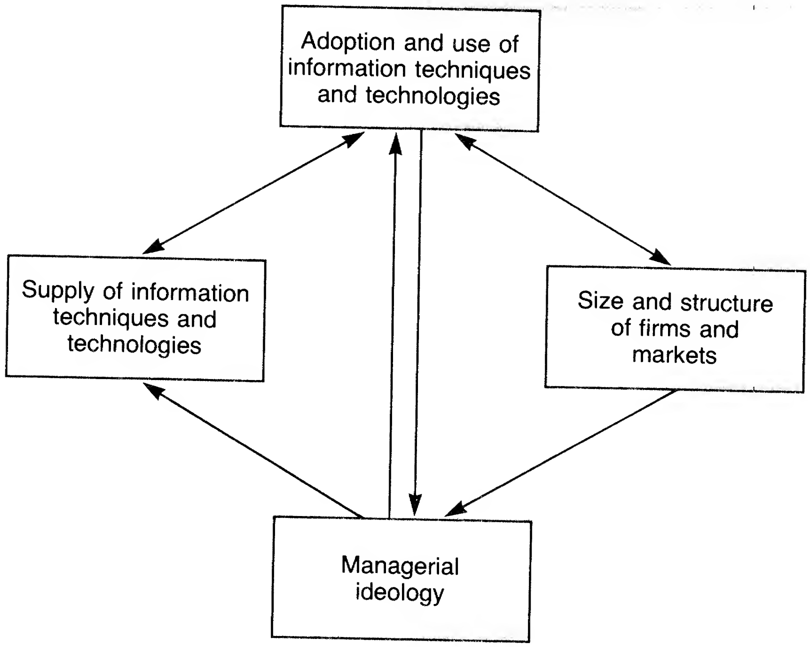

Figure 2.1 Factors influencing the adoption and use of information techniques and technologies

Size and structure

The growth and structural evolution of American firms and markets, the profound changes traced by Alfred D. Chandler, Jr (1977) in *The Visible Hand*, affected the adoption of information techniques and technologies directly by increasing demand for information, though in specific cases the effect was not always simple or immediate. The case of the Scovill Manufacturing Company, a Connecticut brass manufacturer tracing its origins to a partnership established in 1802, illustrates the sometimes complex effects of structural change and growth (Bishop/*c*. 1950; Yates 1989, Ch. 6).

Several interlocking partnerships, each of which produced a different product line (buttons, hinges and photographic plates, as well as semi-finished brass products), were combined when the firm incorporated in 1850. The new company had a workforce of over 150 persons and several departments or 'rooms' (e.g. the casting room) run by skilled workers reporting directly to the owners. According to Johnson and Kaplan (1987), this incorporation into a single firm

of multiple functions previously coordinated by the market should have triggered the adoption of at least primitive cost-accounting techniques based on systematic collection and monitoring of operating information. Such a system, like those developed in a few early nineteenth-century textile firms, would have allowed the owners to monitor their operations to assure that internal, managerial coordination of multiple functions was as efficient as the market coordination that preceded it. At Scovill, this system did not emerge for another two decades, triggered in part by another structural change, the addition of a new layer of management. Around 1870 the first (relatively primitive) cost-accounting system was initiated by a pair of bookkeepers, C. P. Goss and M. L. Sperry, recently promoted to the newly created positions of secretary and treasurer by a company president who did not want to manage the whole operation himself (Bishop/*c.* 1950). This system was implemented through a new information technique, a set of forms they created to collect and compile the necessary operating information.

Growth by itself also put increased demands on the existing information system, as Scovill's adoption of the typewriter illustrates. During the 1880s, Scovill's workforce grew from 400 to over 1,000 employees and its assets from $1,225,000 to $1,657,000. This increase in business was reflected in its growing correspondence with customers, suppliers, and its own stores in New York, Boston and Chicago. In the first years of the decade, the firm's outgoing correspondence filled approximately five 1,000-page press books per year. Between 1883 and 1886, however, the total grew rapidly, and from 1886 into the 1890s, it filled nine to ten volumes per year. In 1888, after the jump in volume, Scovill adopted the typewriter. At that point, the typewriter had been available for over a decade, and the systematic management ideology had not yet been introduced into the firm. Thus the timing strongly suggests that growth was the primary factor driving the firm's adoption of the technology at that time.

In addition to the direct influence of size and structure on the use of information techniques and technologies, at this point it is worth briefly mentioning the reciprocal and mediating forces indicated in Figure 2.1. Information techniques and technologies also played a role in the continued growth and evolution of firms during the early twentieth century. Without the typewriter, for example, the costs of producing all the written communication resulting from continued growth and later systematization in firms like Scovill might have

slowed and constrained that development. Finally, firm size and growth, as indicated in the first half of this chapter, created the conditions that fostered the emergence of the systematic-management ideology, which, as described below, also affected the adoption of techniques and technologies.

Supply of information

The supply of available methods and devices for handling information naturally affected their adoption and use. A firm could not adopt a device or technique that had not yet been developed (although it might invest the time and resources to develop one), and was less likely to adopt one that was obscure or costly. In some cases, the technology or technique existed considerably before it was widely used in business, indicating that other factors were more crucial in its adoption than the supply. For example, carbon paper was available but of limited use in firms until the typewriter made it convenient to use. Similarly, graphs had long been used for demographic and scientific data, but they were only applied to managerial data around the turn of the twentieth century, when the period's burgeoning collection of operational statistics created a new demand. On the other hand, the first half of this chapter demonstrated that the variety and quantity of new devices and techniques for handling information increased greatly during the last decade of the nineteenth century and the first few decades of the twentieth century.

In some cases the supply of techniques and technologies was a critical constraint on a long-standing or newly emerging need. For example, the Illinois Central Railroad adopted the Edison Electric Pen within months of its introduction, in spite of its relatively unsatisfactory performance (Yates 1989, chs 4–5; ICR/). They used it to fill in the names and titles of new managers within divisions in announcements of personnel changes, thus allowing them to save printing costs by having very large numbers of generic announcements printed, rather than relatively small numbers of specific announcements. Few innovations were perfected technically by the time they were introduced, and their manufacturers and new competitors responded to existing and new demand by continued development, as with the typewriter's tab feature, developed to aid in typing tables or filling in forms. In the case of the Hollerith Tabulator, Hollerith recognized that large railroads and other businesses, like the Census Bureau, had extensive

information-processing needs, and he worked with potential customers in developing suitable equipment. This process continued as he improved the various devices in response to suggestions and complaints from existing customers (Austrian 1982). Thus the relationship between supply and adoption of such technologies was reciprocal.

Finally, there is one other relationship with supply indicated in Figure 2.1: the increase in the supply of equipment was also fed by the demand created by the new managerial ideology. William Henry Leffingwell, a well-known office systematizer, offered the following explanation for the growth of the office machinery industry in *The Office Appliance Manual* that he compiled and edited for the National Association of Office Appliance Manufacturers:

> When business method was individual and self-centered and business aims narrow and secretive, there was little incentive for inventive genius to burn the midnight oil in the search for business machinery. The demand for mechanical office appliances did not exist because there was no similarity of method. But as similarity of method spread through the exchange of ideas, the possibilities for mass production attracted some of the keenest minds in the country, who turned to making machines and devices that would simplify the mass of problems crowded into the business man's day. As a result, an immense industry has been created – an industry which produces office machines and devices for the entire world.
>
> (Leffingwell 1926: 18)

The existence of a wide market of businesses all facing similar information-handling tasks made the development and sale of office devices and supplies from tabulators to forms an attractive business prospect. Thus the supply of information techniques and technologies was influenced by the similarity of methods encouraged by the exchange of ideas about systematic management in the managerial literature.

Managerial ideology

This link between supply and systematic management brings us to the third major factor in the rapid spread of the bureaucratic and mechanical devices described earlier: managerial ideology.[5] The growth and evolution of firms and the resulting chaos and diseconomies of scale certainly created a demand for better coordination

and control, but more than one approach to the problem was possible and may even have been functional.[6] Moreover, although aspects of systematic management emerged from functional responses to specific situations on the part of innovators like Metcalfe, the ideology formulated by Metcalfe and others in the process of these responses gained a life of its own. The American business community's wholehearted embrace of the values, language and mechanisms of systematic management reflects not just economic rationalism, but also the managerial community's acceptance of a specific ideology of managerial coordination and control.

As the earlier description of systematic management reveals, this ideology involved beliefs both in internal efficiency as the highest goal and in system as the way to achieve efficiency. System in turn depended on written documentation of procedures and of operating information, both for immediate use and for later reference. This ideology became an important factor in the proliferation of information techniques and technologies; at the same time, this proliferation reinforced the ideology. This mutually reinforcing dynamic operated through several (and often interlocking) motives or mechanisms.

Function/cost

The ideology of systematic management called for uses of information and communication not previously seen as desirable – functions such as recording, analysing and reporting extensive internal operating information up the hierarchy, or conveying rules and regulations to employees in relatively permanent written forms. In many cases, firms could achieve these functions with existing techniques and technologies but perhaps slowly and at great expense. Newer technologies might substantially reduce the time and cost of doing so. Thus the systematic management ideology reinforced the acquisition and use of new techniques and technologies by reducing costs and supporting new functions. In the same way, the new techniques and technologies reinforced the ideology. That is, the new methods of collecting and processing information were so rapid and inexpensive that they encouraged new uses of data not thought of by the original systematizers. The influences thus reinforced each other. While cost or function is a standard economic force if we assume that the new uses of information were chosen as the economically optimal method of coordination within the firm, in many cases these uses were chosen on ideological grounds.

Let us examine some instances exhibiting this force. The systematic management ideology called for the systematization and communication of procedures by a downward flow of written rules and orders. In 1887, when Scovill already employed about 1,000 people in several departments but before the ideology of systematic management had been introduced into it, Scovill's top management opposed on principle any written policies:

> We have never had any shop rules printed. There is a general understanding that ten hours constitutes a day's work and that the hands are expected to do a day's work if they get a day's pay. Each department is under the direction of a foreman, in whom we trust and who sees that the hands are industrious and attend to their business. If they do not do it, he sends them off and gets others. . . . We do not think printed rules amount to anything unless there is somebody around constantly to enforce them and if such a person is around printed forms can be dispensed with.
>
> (Bishop/*c*. 1950: 205)

But in the early twentieth century John H. Goss, the Yale-educated son of the firm's president, introduced the modern ideals of systematic management into the firm. After his schooling, where he was evidently exposed to the new ideas about management, he returned to the firm first as an apprentice production worker, then moved into his first lower-level management job. As he later described his experience:

> That was the first time it came to my attention forcefully that my college education had done me any good, because I discovered that there was a complete lack of system and I started in to try and see how I could introduce a little system into at least the immediate area in which I was working.
>
> (Scovill 2/58, 5 December 1935)

Although workforce growth in the years since the statement against written orders had been moderate and although he started out in charge of a single, relatively small department, Goss immediately instituted a downward flow of general bulletins and specific written orders within that department, in spite of 'at least passive resistance from every direction'. As he moved up to become General Manager a few years later, he did likewise for the firm as a whole. As his description suggests, he was motivated less by specific situations than by a learned belief that system was good.

This shift in managerial ideology created a new communication

function, thereby creating a need to disseminate the orders and to store them accessibly. Because the firm lacked duplicating equipment when Goss began to issue such bulletins, the original was typed with several carbon copies, which were then circulated around the departments. While additional originals and carbon copies could have been typed to allow each recipient to keep a copy, that more expensive procedure was not followed. Soon, however, some of the foremen receiving copies of the notices decided to have them retyped for local storage and reference before passing them on. That procedure created the need for more typing and for additional filing equipment. Both Goss himself and at least one of the foremen acquired Shannon files, a specialized form of box files, in which to store their own copies of such orders. In the second decade of the twentieth century, the firm acquired duplicating equipment, which eliminated the need for retyping, and vertical filing equipment, which provided more accessible storage. Thus when Goss introduced the values of systematic management into the firm, they spurred the gradual acquisition of new technologies and techniques to enable the firm to accomplish the new functions at an acceptable cost.

Scovill's systematization continued through the first two decades of the new century. By the final days of the First World War, which had been a period of enormous firm growth and increased establishment of upward reporting systems, a statistician named E. H. Davis was hired to systematize the reporting system itself and to extend Scovill's statistical analysis of the voluminous data it was collecting. Davis immediately requested a Powers tabulating machine for his new Statistical Office. He justified his request as follows:

> The Powers Machine will open up a large field of statistical investigation and presentation. A certain amount of preliminary experimentation is necessary in handling data susceptible of treatment in any one of several ways. This machine will make possible a series of provisional experiments now prohibitive on account of the time and labor required, and will facilitate actual operation along the lines eventually adopted.
>
> (Scovill 2/34, 8 November 1918)

He acquired the tabulator to perform additional data manipulations that would have been too costly and time-consuming without it. Having the machinery, of course, no doubt further reinforced the systematic management ideology by letting Davis carry information analysis further than the original systematizers of the late nineteenth century would have dreamed possible.

Fad/symbolism

While in the cases discussed above, new techniques and technologies were adopted to reduce the cost of achieving additional information functions demanded by systematic management beliefs, in other cases managers adopted such devices less out of a desire for efficiency than out of desire to signal that they were modern and up to date. Uses of information, as well as clerical and mechanical devices that evolved to support these uses, themselves became symbols of modern methods, and were often adopted (or avoided) on that basis, even when adoption was not economically justified.

Again, let us look at examples of this effect. In the late nineteenth century, Du Pont was still run by an extremely conservative older generation – so conservative that firm head, General Henry du Pont, insisted on using a quill pen for his own correspondence long after the more efficient and cost-effective steel- or gold-tipped pens had replaced quills for standard business use (Yates 1989, ch. 7; Du Pont/). Only a secret plot by his clerks in the 1880s finally succeeded in getting a typewriter into the office. At this stage, ideological symbolism retarded changes justified by function and cost. In contrast, Francis G. du Pont, of the next generation of the family, eagerly adopted the typewriter and all of the duplicating and filing equipment becoming popular in the 1880s and 1890s. He obviously wanted to be seen as an up-to-date, modern manager. His management methods, however, were shoddy and erratic, showing none of the system suggested by his adoption of such devices. He used the typewriter himself, for example, rather than gaining its real efficiency by hiring a trained typist. In fact, his unsystematic management of the Carney's Point smokeless powder factory and experimental laboratory was a factor in driving his nephew Pierre du Pont, to leave the firm (Chandler and Salsbury 1971). Only when Pierre, along with two cousins of his own generation, returned to take over the firm in 1902 did the firm really modernize and systematize its management methods. Thus Francis G. du Pont's use of new information technologies, like General Henry's avoidance of them, was driven primarily by ideological symbolism or fad, rather than by a desire to reduce the cost of achieving new information functions.

The influence of the fad for systematization is also evident in a tendency for firms to institute too many systems of forms and reports initially, then to retrench after further examination. E. H. Davis, the Scovill statistician who obtained the Powers tabulator, initially attempted to make his office a clearing house for routine reports,

compiling lists and copies of all such reports (many of them on standardized forms) that were supposed to be sent to the General Superintendent's office. In doing so, he discovered several superfluous reports, some of which had already been silently discontinued. Many of these reports had been established over a decade earlier when J. H. Goss was most intent on systematizing the firm. In the process, Goss had evidently requested some reports that either were never really functionally necessary to his job as general superintendent or no longer served a useful purpose. When Davis brought them to his attention, Goss eliminated them, noting, 'I am giving up certain reports that do not seem to me worth while to continue further in view of the labor required to compile them' (Scovill 2/34, 25 April 1921). Thus Davis' efforts revealed that the use of form reports had exceeded the level justified by cost, probably driven by their symbolic value. Moreover, this unnecessarily increased level of reporting may well have further spurred the adoption and use of other devices and techniques to reduce the time and cost of storing and analysing it.

Role models

A different type of mechanism diffusing the systematic management ideology and the supporting information techniques and technologies (while reinforcing their relationship), was the increasing availability of role models. Individuals or firms that had adopted the ideology or some particular technology could subsequently become role models for others who had not yet done so. This mechanism could operate in conjunction with either of the motives just discussed. For example, potential users of a specific technology could observe how current users have reduced cost or increased functionality in achieving some goal of systematic management, then decide to follow the role models. Conversely, potential users could, for primarily symbolic reasons, imitate role models using a particular technology, without clear functional needs of their own. The role-model mechanism contributed to the self-reinforcing cycle, since every adopter of a technique or ideology increased the number of potential role models available to others.

Scovill's adoption of vertical filing in the second decade of the twentieth century demonstrates the role-model mechanism. In 1911, Scovill took the necessary first step of giving up press copying into bound volumes in favour of carbon copying, which produced loose copies. This change was evidently aimed at facilitating duplication,

not storage and retrieval, for the firm initially proceeded to bind the loose carbon copies into volumes separate from incoming documents. Within a year, however, the firm had begun to look to role models for guidance in storage and retrieval systems. It investigated filing practices at a similar brass company, resulting in a report entitled 'Vertical letter filing; as practiced by the Bridgeport Brass Co.' (Scovill 2/26, 12 December 1912). This detailed report described the organization, principles, equipment and procedures used by Bridgeport, noting especially Bridgeport's total dependence on carbon copying and its combining of all correspondence (internal and external, received or sent) about each customer in a single file. One year after this report, Scovill announced to its New York store the firm's own impending conversion to a comparable system of vertical filing. Although this example clearly involves a role model, the effect could be reinforcing function or fad. Immediately before the new system was instituted (but almost a year after the investigation of filing at Bridgeport Brass), a letter from headquarters to the New York store revealed a failure to locate a document in the old system:

> Replying to yours of the 24th regarding terms to Jos. L. Porter & Co., we are sorry that our record for 1908 is quite as inaccessible as yours seem to be, and, unless you consider the matter of enough importance, you will let the matter pass
>
> (Scovill 1/558, 26 December 1913).

This breakdown in the information-retrieval system might suggest that the role modelling was working in conjunction with functional needs. However, the incident occurred well after the initial investigation and too close to the final conversion to vertical files to have played a direct role in it. Thus, in the absence of other such evidence, the possibility remains that the incident may have been an isolated one, and that Scovill imitated Bridgeport Brass for more symbolic reasons. In either case, the adoption reinforced the growing business use of such technologies and created another potential role model.

CONCLUSION

The virtual explosion of information and communication technologies and techniques within firms during the decades surrounding the turn of the century transformed the American office and the role of information in business. By 1920, this transformation was virtually complete, and changes came more slowly and incrementally in the subsequent three decades. It was not until the introduction of the

computer into post-Second World War businesses that a comparably rapid period of change began. As I have tried to illustrate, neither the supply of technological innovations nor changes in the size and structure of firms alone or together account for the full extent of this revolution. The systematic management ideology, with the premium it placed on managing through written information, reinforced the adoption of new devices and techniques, which in turn reinforced the ideology by reducing the cost and increasing the symbolic attractiveness of following it.

This look at events beginning over a century ago suggests some questions to ask about contemporary developments. Is the current computer revolution driven solely by technological breakthroughs that have radically increased the supply of information technology? Now, in the midst of the transformation, supply often seems to dominate. But this modelling of factors in an earlier information revolution suggests that we might look for other contributing factors, including ideological ones. One function of historical analysis is to allow us to observe such dynamics unclouded by our own role in them, and then to use them in formulating questions about what is occurring around us today.

NOTES

1 I would like to thank Paul Krugman for suggesting this approach to presenting my argument to economists. I appreciate the comments I received on an earlier draft of this chapter from participants in Harvard's Business History Seminar (especially Kenneth Lipartito, William Mass, Thomas McCraw and Alfred D. Chandler, Jr.) and from Naomi Lamoreaux. At a later stage, I benefited from the comments of participants in the conference on 'Global Perspectives on Business Information' at the University of Reading.

2 Many aspects of this transformation are traced and documented in detail in Yates (1989). Material in this paper not otherwise cited is from that source. See also Yates (1991) for treatment of the supply of techniques and technologies.

3 Some factories had printed lists of rules, made up by the owners or factory managers and posted throughout the factory; however, as Daniel Nelson has noted, even in these cases, 'the shop rules were largely what the foreman made them'.

4 The broad but amorphous systematic management movement should not be confused with the more narrowly focused scientific management movement which emerged around the turn of the century and which assumed that many of the basic principles and practices of systematic management were already in place. While Frederick Taylor and his followers focused on the very specific techniques for improving efficiency

on the shop floor, the broader movement was concerned with systematizing operations at all levels from the top to the bottom of the firm. For discussion of the relationship of these two movements, see Nelson (1974, 1980); and also Kendall (1912).

5 Ideology is pervasive and influential on many levels and in many ways. Putting ideology in a box in Figure 2.1 in some sense obscures that fact. Nevertheless, for analytic clarity, I have isolated it in the figure and focused on a particular level of ideology and its influence.

6 For example, one response would be to return some of the coordination to the market by returning to smaller, single function firms. Another would be to adopt oral and consultative approaches similar to those adopted somewhat later by Japanese firms. The more general, cultural ideology of the time, however, was shifting from communal towards bureaucratic and hierarchical approaches to achieving order, as Wiebe (1967) has demonstrated. This underlying ideology also helps explain similarities in the approaches of the railroad managers and the manufacturing managers to similar problems, even though there is no evidence that the former influenced the latter.

BIBLIOGRAPHY

Archival sources

Scovill's records are housed in the Baker Library, Harvard Business School.

Bishop/*c*.1950, P. W. Bishop, unpublished manuscript history of the Scovill Manufacturing Company, Scovill Collection 2, Case 59, Baker Library, Harvard Business School.

Quotations from the other Scovill archival materials are referenced in the text in the following abbreviated forms:

Scovill 2/26, 12 December 1912.
Scovill 1/558, 26 December 1913.
Scovill 2/34, 8 November 1918.
Scovill 2/34, 25 April 1921.
Scovill 2/58, 5 December 1935.

Du Pont/The records of the Du Pont Company, Hagley Museum and Library, Wilmington, Delaware.

Edison/1876 'Edison's Electrical Pen and Duplicating Press', 1876 advertising circular, Edison National Historic Site, Menlo Park, New Jersey.

ICR/ The records of the Illinois Central Railroad, Newberry Library, Chicago.

WEC/1883 'Catalogue of telegraph instruments and supplies', Western Electric Company, 1883, Trade Catalogues, Hagley Museum and Library, Wilmington, Delaware.

REFERENCES

Arnold, H. C. (1901) *The Complete Cost-Keeper*, New York: The Engineering Magazine Press.

Austrian, G. D. (1982) *Herman Hollerith: Forgotten Giant of Information Processing*, New York: Columbia University Press.

Barnum, C. L. (1925) 'The layout and arrangement of printed forms', *The Office Manager* 1 (April): 75–6.

Beniger, J. R. (1986) *The Control Revolution: Technological and Economic Origins of the Information Society*, Cambridge, MA: Harvard University Press.

Bismer, J. (1911) 'Graphs: charts that illustrate the comparative value of figures; how they are made up and how they are used as time-savers and danger signals', *System* 20: 270–6.

Brinton, W. C. (1914) *Graphic Methods for Presenting Facts*, New York: Engineering Magazine Co.

Burt, C. A. (1910) 'Advantage of written orders', in P. W. Lennen, William Klendenin, E. T. Page, Glenn S. Noble, George B. Spencer and others (eds), *Business Correspondence*, vol. 2 of the Businessmen's Library, Chicago: System Co.

Chaffee, A. (1938) *How to File Business Papers and Records*, New York: McGraw-Hill Book Co.

Chandler, A. D., Jr (1977) *The Visible Hand: The Managerial Revolution in American Business*, Cambridge, MA: Harvard University Press.

Chandler, A. D., Jr and Salsbury, S. (1971) *Pierre S. du Pont and the Making of the Modern Corporation*, New York: Harper and Row.

Church, A. H. (1900) 'The meaning of commercial organization', *Engineering Magazine*, 20: 391–8.

—— (1913) 'Practical principles of rational management', *Engineering Magazine* 45: 673–80.

Clark, E. A. (1916) 'How we keep costs in our 75-man plant', *Factory* 17: 405–8.

Funkhouser, H. G. (1937) 'Historical development of the graphical representation of statistical data', *Osiris* 3: 281–342.

Geertz, C. (1964) 'Ideology as a cultural system', in D. Apter (ed.), *Ideology and Discontent*, New York: Free Press.

Griffith, J. B. (ed.) (1905) *Systematizing*, 2 vols, published by The International Accountants' Society, Inc. Detroit: The Book-keeper Press.

Hudders, E. R. (1916) *Indexing and Filing: A Manual of Standard Practice*, New York: The Ronald Press Company.

Johnson, H. T. and Kaplan, R. S. (1987) *Relevance Lost: The Rise and Fall of Management Accounting*, Boston: Harvard Business School Press.

Kendall, H. P. (1912) 'Types of management: unsystematized, systematized and scientific', in *Addresses and Discussions at the Conference on Scientific Management Held Oct. 12, 13, 14, 1911*, Hanover: Dartmouth College Conferences.

Koon, S. G. (1913) 'Hollerith tabulating machinery in the business office', *Machinery* 20: 25–6.

Leffingwell, W. H. (1917) *Scientific Office Management*, New York: A. W. Shaw Co.

—— (ed.) (1926) *The Office Appliance Manual*, National Association of Office Appliance Manufacturers.

Lewis, S. (1899) 'Works management for the maximum of production: organizations as a factor of output', *Engineering Magazine* 18: 59–68.

Litterer, J. (1961a) 'Alexander Hamilton Church and the development of modern management', *Business History Review* 35: 211–35.

—— (1961b) 'Systematic management: the search for order and integration', *Business History Review* 35: 461–76.

—— (1963) 'Systematic management: design for organizational recoupling in American manufacturing firms', *Business History Review* 37: 369–91.

Metcalfe, Capt. H. (1885) *The Cost of Manufactures and the Administration of Workshops, Public and Private*, 3rd edn New York: John Wiley & Sons, 1894.

—— (1886) 'The shop-order system of accounts', *Transactions of the American Society of Mechanical Engineers* 7: 440.

Millard, A. (1990) *Edison and the Business of Innovation*, Baltimore: Johns Hopkins University Press.

Morse, F. C. (1900) 'Keeping accounts without books', *System* 1 (September): n. p.

Nelson, D. (1974) 'Scientific management, systematic management, and labor, 1880–1915', *Business History Review* 48: 479–500.

—— (1978) *Managers and Workers: Origins of the New Factory System in the United States 1880–1920*, Madison: University of Wisconsin Press.

—— (1980) *Frederick W. Taylor and the Rise of Scientific Management*, Madison, WI: University of Wisconsin Press.

Norberg, A. L. (1990) 'High-technology calculation in the early 20th century: punched card machinery in business and government', *Technology and Culture* 31: 753–79.

Parsons, C. (1909) *Business Administration*, New York: System Co.

Proudfoot, W. B. (1972) *The Origin of Stencil Duplicating*, London: Hutchinson and Co.

Russell, H. S. (1917) 'Factory purchasing system – methods and records', *Industrial Management* 53: 694.

Shattuck, G. A. and Kapp, E. B. (1926–7) 'Accounting by tabulating machines', *Harvard Business Review* 5: 80–94, 213–18.

'System for factory purchases' (1903) *System* 3 (January): n. p.

US Bureau of the Census (1960) *Historical Statistics of the United States, Colonial Times to 1957*, Washington, DC: U.S. Government Printing Office.

Wiebe, R. H. (1967) *The Search for Order: 1877–1920*, New York: Hill and Wang.

Williams, M. R. (1985) A History of Computing Technology, Englewood Cliffs, NJ: Prentice-Hall.

Wilson, C. E. (1901) 'Filing Correspondence', *System* 1 (July): n. p.

Yates, J. (1982) 'From press book and pigeonhole to vertical filing', *Journal of Business Communication* 19: 5–26.

—— (1989) *Control Through Communication: The Rise of System in American Management*, Baltimore: Johns Hopkins University Press.

—— (1991) 'Investing in information: supply and demand forces in the use of information in American firms, 1850–1920', in P. Temin (ed.) *Inside the Business Enterprise*, Chicago: University of Chicago Press.

S1-17

3 The Railway Clearing House and Victorian data processing[1]

WS *Martin Campbell-Kelly*

DP3 LPL 45

N71

BACKGROUND

Since the early 1960s, there have been a number of American studies of the 'information revolution'. The first of these studies was the seminal work of Fritz Machlup (1962) who demonstrated using census data that 'knowledge work' was growing faster than the other broad occupational sectors (i.e. agriculture, industry and services) and would soon become the largest sector. This work was followed by the much more detailed study of Marc Porat (1977) who, again using census data, analysed the growth of the information economy over a much longer period of time using the census reports from 1860 up to recent times. One of Porat's results was to show that between the 1870 and 1890 censuses, the information sector grew from 4.8 to 12.4 per cent of the labour force, while the labour force itself grew from 12.5 million to 22.8 million. In both of these studies the information economy was very broadly defined – as including education, financial services, publishing, research and development, etc. A sizeable proportion of the new information workers were engaged in routine clerical activity in the large-scale offices that developed from the 1870s.

The growth spurt in the number of office workers in the United States during the closing decades of the nineteenth century occurred in parallel with the development of office machinery. As a result, the two events have been seen by a number of writers (e.g. McLaughlin and Birinyi 1980; Giuliano 1982; Beniger 1986) as going hand in hand: the office machine was the technology that enabled the large-scale office to flourish. To a first approximation this is a correct interpretation, although as JoAnne Yates (1989) has recently shown some large-scale offices were already in existence that embraced the new office technology as soon as it became available. The situation

in Britain, however, was quite different: the large-scale office developed much earlier and became mechanized much later. In Britain, the rapid growth in clerical work took place between about 1850 and 1870:

> Those occupations concerned with the provision or exchange of goods and services, especially those connected with commerce, banking and insurance, grew more rapidly than most other employment sectors. There was a similar proliferation of clerical jobs in the large bureaucracies such as central and local government and the railways. Commercial occupations grew from 91,000 in 1851 to 212,000 in 1871, to 449,000 in 1891 and finally to 739,000 in 1911. Within this broad category commercial clerks expanded faster than any other group, from 48,689 in 1841 to 181,457 in 1881 and to 477,535 in 1911.
>
> (Anderson 1976: 52)

Large-scale offices developed in Britain in the wake of urbanization in the 1840s – they were completely unmechanized, and every transaction was performed by clerk, steel nib and paper. These offices sprang up to supply the market for services needed by the industrial classes: industrial insurance, banks for small savings, cheap rail travel, etc. This market was characterized by a very high volume of low financial-value transactions. Up to the 1840s, almost all financial services had been provided for the middle classes, in which a cost-per-transaction of a few shillings was acceptable in the context of (say) an insurance policy with a £5 annual premium, or a movement of £100 on a bank account. But for an organization to deal with working-class financial transactions of a few shillings or less, the cost-per-transaction had to be reduced to a few pence. In the new-style Victorian office this was achieved by organizational innovation combined with massive economies of scale. From the typical 1840s office with a few clerks processing a few thousand transactions a year, emerged the large-scale Victorian office with hundreds of clerks processing millions of transactions. Among the most important of these large Victorian offices were the clearing houses; and pre-eminent among the clearing houses was the Railway Clearing House.

DEVELOPMENT OF THE RAILWAY CLEARING HOUSE

During the 1830s the embryonic British railway network had developed in a *laissez-faire* manner with no conscious effort to build a transport 'system'. There are many well-known examples of the

problems that this unbridled competition led to: isolated lines that did not connect with those of other companies; the wasteful duplication of lines connecting major centres; the lack of a standard gauge, and so on.

By 1840, there were about 1,500 miles of railway track laid; some of the early gauge and standardization problems had been resolved, and the lines of several different companies had become connected. It was possible for passengers to make long journeys – for example, from London to Newcastle – but only by passing over the lines of several different companies (five in the case of London to Newcastle).

Dealing with the revenues from long-distance passenger traffic led to formidable administrative and accounting difficulties for the railway companies. Thus, in the case of our passenger from London to Newcastle, each of the five companies involved had to be compensated for its contribution to the total journey. Initially, private arrangements were made between the companies for through-passenger traffic so that a composite fare could be divided up between them. Even with two or three operators this was an accounting challenge, but with more operators it became what Lardner (1850: 150) described as 'an intolerable chaos of cross accounts'. Often railway companies were unable to agree on terms for a composite fare, so that passengers would be 'turned out of their compartments' at the junction between major operators in order to buy tickets for the next leg of the journey (Bagwell 1968: 27).

Most authorities attribute the idea of establishing a Railway Clearing House to George Carr Glyn (*DNB* 1797–1873) and Kenneth Morison (?–1861). Glyn was a partner of the banking firm of Glyn, Mills and Currie, and chairman of the London and Birmingham Railway. Morison was chief accountant of the London and Birmingham, and became the first executive secretary of the Railway Clearing House. The idea of using a clearing system for transport was not, in fact, unprecedented. There was already a small clearing system operated by the Golden Cross Coach Company for through-passenger traffic (Bagwell 1968: 35; Sherrington 1937, vol. 2: 71). But, in terms of organization, the Railway Clearing House was more directly inspired by the Bankers' Clearing House, on whose executive committee Glyn sat (Fulford 1953).

The Bankers' Clearing House was itself a major Victorian data-processing operation. It was established in an *ad hoc* way in the 1770s so that at a fixed time and place each working day, the London banks could clear cheques with one another. The chief advantage of the clearing operation was that it reduced the reserve of cash needed for

settlements between the banks, since the only money exchanged between them was *the difference* between the amounts they owed each other. The Bankers' Clearing House was formally incorporated in 1805, and by 1839 some thirty banks were clearing £954 million annually, with a daily average of about £4 million (House of Commons 1841).

In 1841, George Carr Glyn persuaded his own and eight other railway companies to jointly subscribe to a railway clearing system. The initial emphasis was to be on the highly profitable through-passenger traffic. Under the clearing system, passengers would be able to 'book through' from any station to any other station within the network served by the clearing house. The clearing house would then be responsible for distributing the fares between the participating companies.

The Railway Clearing House began operation on 2 January 1842, with George Carr Glyn as chairman, Kenneth Morison as its part-time executive secretary, and six full-time clerks. The railway clearing system was an immediate success. By 1845, a total of 16 companies had joined the system, and over half-a-million passengers were being booked through a year (Morison 1846). By 1848, 43 railway companies had joined up, and the following year the Railway Clearing House staff had grown to 45 clerks. It was now possible to book through between any pair of the 887 stations in the system. The clearing of through-passenger traffic culminated with the Great Exhibition in 1851 which produced an enormous surge in traffic, and for which the clearing house made special arrangements to cope with the high volume of low-value excursion fares.

From 1847, the clearing house also began to take on the transmission of parcels and goods. This was quite slow to develop at first because of competition from the established private carriers, such as Pickfords, and Chaplin and Horne, which had hundreds of booking offices around the country and used whatever combination of road, rail, canal and sea transport that was most effective. But as the railway network became more developed, rail-only goods transport became competitive. The goods traffic passing through the railway clearing system soon outgrew that of the private carriers, and by the 1860s that aspect of their business was in decline (Turnbull 1979: 106–45). This was in marked contrast to the United States which had no equivalent of the Railway Clearing House, and where firms such as Wells Fargo prospered for decades longer than the British private carriers.

As the clearing operation grew, particularly following the railway

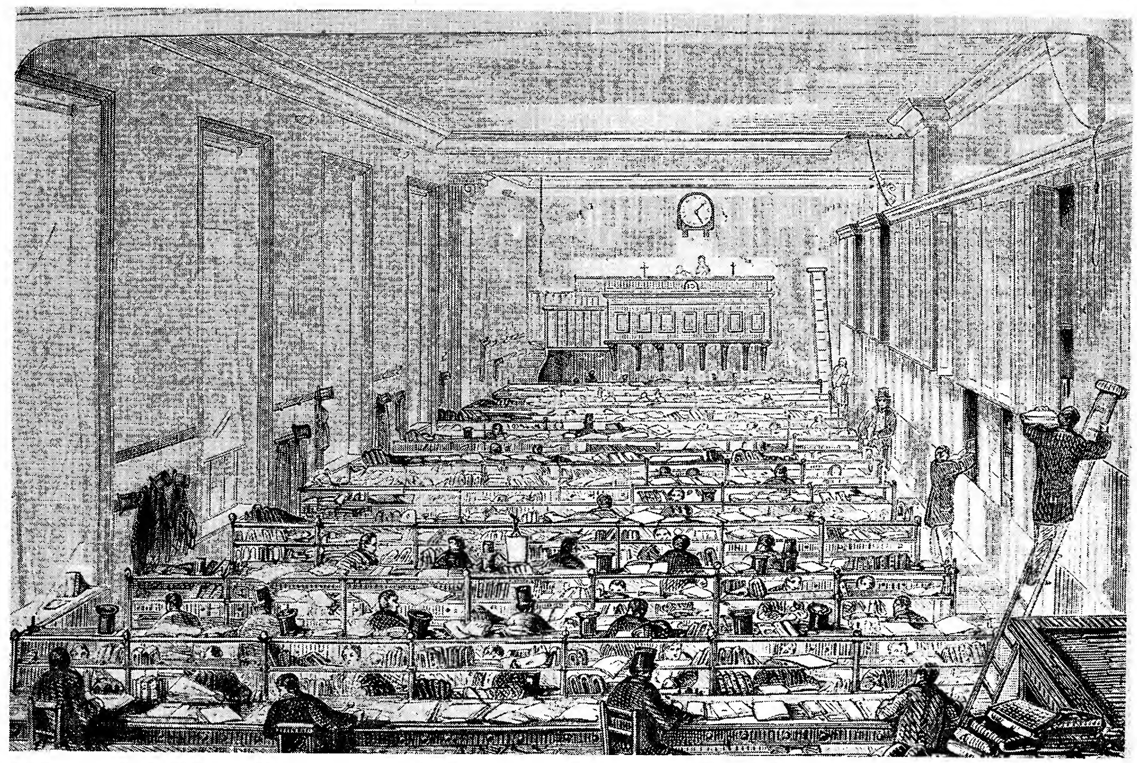

Figure 3.1 Long Office of the Railway Clearing House, 1864
Source: *Cassell's Illustrated Family Paper*, 8 October 1864: 318. By permission of the British Library.

mania of 1846–7, office accommodation became a constant and pressing problem. In 1849, the clearing house moved from *ad hoc* accommodation near Euston Station in London to more spacious offices in Seymour Street. But within a couple of years, Morison was pleading with his Superintending Committee:

> if the business of the Clearing House continues to increase, the office must be enlarged. It is also necessary that steps should be taken to improve the mode of ventilating the rooms; they cannot in fact be ventilated at present without producing cold currents of air, which are very injurious, and have, I fear, in one or two instances proved fatal to the clerks.
>
> (Bagwell 1968: 137)

As a result, the premises were enlarged to construct the famous 'long office' which was probably the largest single office in the country when it was completed in 1855 (Figure 3.1).

As the nation's railway network continued to expand during the 1850s, the clearing system grew to meet the increased volume of traffic. By 1861, the year that Morison died in office, there were nearly 500 clerks in the clearing house, organized into four functional divisions. Morison's successor as secretary was his protégé P. W. Dawson (one of the original 6 clerks taken on in 1842). Dawson immediately instigated a major reorganization to cope with the growing volume of goods and parcels traffic. By 1864 there were a total of 873 clerks in the clearing house, and Dawson, like his predecessor, was pleading for more office space because, apart from gross overcrowding, 'the cubic amount of breathing space per clerk was considerably less than that required to preserve a good state of health' (Bagwell 1968: 159).

In 1864, the clearing house processed a total of 1.6 million settlements between the railway companies (Table 3.1). As the

Table 3.1 Railway Clearing House statistics, 1864–1914

	Number of goods and passenger settlements (millions)	*Total value of settlements (£ millions)*	*Number of clerks*
1864	1.6	8.9	873
1874	4.9	16.1	1,325
1884	8.1	17.6	–
1894	10.2	19.6	1,600
1904	15.9	26.3	–
1913	17.6	33.2	2,503

Source: Bagwell 1968: 300–1, 306.

volume of data processing increased, however, productivity steadily improved in terms of the number of transactions processed per clerk. Thus, by 1874 the number of settlements had trebled to 4.9 million, but the staff numbers had increased by only approximately 80 per cent to a total of 1,325. By the mid-1870s the Railway Clearing House was in its heyday. It was a brief period of time between the system being fully perfected but before bureaucratic fossilization had set in.

THE RAILWAY CLEARING HOUSE IN 1876

The *technique* of data processing tended to go unrecorded in large Victorian offices. There was an oral tradition and a system of apprenticeship; and there were generally no manuals of office practice or written specifications of how the system operated. The Railway Clearing House, however, provides a welcome exception to this general pattern. In 1877 a Major T. F. Dowden – whose position within the Clearing House is unknown – compiled a remarkable 188-page book entitled *The Railway Clearing System as Practised in the English Clearing House in 1876* (Dowden 1877). This book describes in great detail the entire clerical operation. It thus represents a fine-grained snapshot of a Victorian office in 1876, which appears to be unique of its kind.

General organization and staff

In 1876 the Railway Clearing House was in its prime. It was a mature, modern organization respected worldwide. Fifty years on it would be a moribund bureaucracy almost beyond redemption – but in 1876 it was an efficient hive of activity. There were a total of 1,440 clerical staff, plus approximately 500 'number-takers' – of whom more later. The staff was organized into three large divisions (Figure 3.2): the Coaching Department with 352 clerks; the Mileage and Demurrage Department with 276 clerks and about 500 number-takers; and the Merchandise Department with 720 clerks. In addition there was a small Lost Luggage Department with just 16 clerks.

The function of the Coaching Department was to divide up the receipts from passenger and parcel traffic between the member companies. This, of course, was the primary function for which the clearing house system was originally devised. The department was headed by an assistant secretary and divided into seven sections. There were three Passenger Sections with 55 clerks each to deal with the passenger traffic receipts; three Parcels Sections with 50 clerks

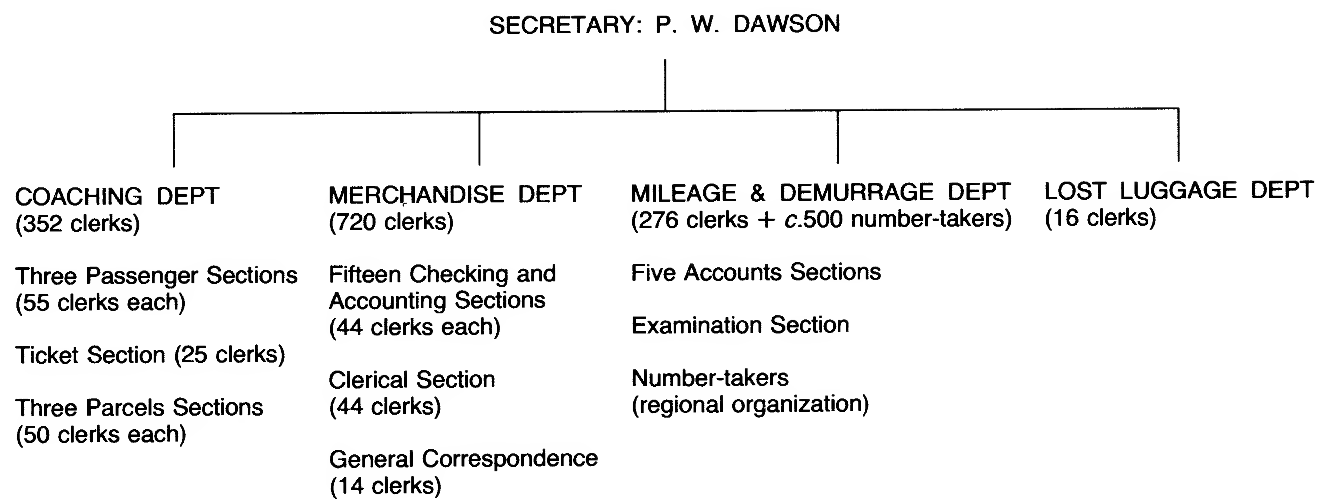

Figure 3.2 Railway Clearing House organization, 1876

each for the parcels traffic; and a small Ticket Section with 25 clerks that processed passenger tickets. Each section was headed by a senior clerk, and the subordinate clerks – men and boys – had a range of experience and pay scales. It took approximately three months for a newly recruited clerk to pass the novitiate stage, and clerks were not considered experienced until they had five or more years' experience. Thereafter the work of the time-served clerk was unchanging and monotonous. There is no evidence that people were moved around to vary their experience; the number that rose to become head of a section was very small; and the chances of promotion beyond that were effectively non-existent. The lot of the Railway Clearing House clerk was not a happy one – besides the tedium of the job and the small promotion prospects, it was badly paid, the working conditions were dismal, and the working hours were frequently extended by unpaid, involuntary overtime. The only redeeming feature was that it was a very secure job: but in the booms between recessions there was always an exodus of the more mobile.

The largest division in the clearing house was the 720-strong Merchandise Department which was responsible for dividing the revenues from goods traffic. It was divided into sixteen sections each of 44 clerks – fifteen Checking and Accounting Sections which divided the traffic receipts, and a Clerical Section which handled the original traffic receipts in an analogous way to the Ticket Section of the Coaching Department. Finally, there was also a small General Correspondence section of 14 clerks. The Merchandise Department performed essentially similar functions to the Coaching Department, but it was much larger because the goods traffic had a higher volume and a far more complex tariff. For the latter, there was a 200-page goods-classification system, which divided goods into five great classes with hundreds of different articles in each class:

> Some idea of the very miscellaneous descriptions of articles carried by railway may be formed from the fact that there are more than 200 items which are grouped as 'explosives and other dangerous goods'; and under the head of 'hardware' there are nearly as many, such as, 'nut-crackers,' 'dust-pans,' 'coffin-furniture' and 'fire-guards,' 'hand-cuffs' and 'Jews-harps,' 'cork-screws' and 'sardine-tin openers,' 'sugar-nippers' and 'warming-pans,' &c., &c. All merchandise and minerals which are enumerated in the different classes are charged by weight and for the distance carried.
>
> (McDermott 1890: 18)

The Mileage and Demurrage Department was the smallest of the three great departments, but by far the most interesting. By the 1870s, the British railway network was very well integrated and it was possible for a railway company to transport a wagon-load of merchandise by using any convenient vehicle suitable for the purpose, whether or not the company owned it, attaching it to a goods train, whether or not the company owned it, and using the lines of any other company. It was the *mileage* function of the clearing house to divide the money received between the many operators who participated in this process – the company that organized the train, the owner of the wagon, the providers of the railway lines, and the providers of the terminal facilities. In addition, a system of fines – known as *demurrage* – ensured that unused rolling stock was speedily returned to the owner.

In the following two sections of this chapter, two of the clearing house's operations will be described in some detail – the division of traffic receipts in the Coaching Department, which was probably the simplest task in the organization; and the Mileage and Demurrage Department which was probably the most complex. The most striking feature of all the Railway Clearing House's data-processing operations is that they were entirely paper-based. In many ways, the history of the Railway Clearing House is a hymn to the standard form (Figure 3.3).

Passenger-traffic receipts

Like many large-scale data-processing activities, the division of passenger-traffic receipts was simple in principle but complicated in practice. As a contemporary writer noted 'the whole system is simplicity itself', but the 'practical details are colossal in number' (McDermott 1890: 11).

The simple principle was that the fare paid by a through-passenger would be divided between the companies over whose lines the passenger travelled. What made the system complex was dividing up the journey into its constitutent parts, and the complexities of the different fare structures. The inputs to the system were the monthly returns from the booking offices of the railway companies, and the tickets collected from passengers at their journeys' end.

The Railway Clearing House supplied all through-passenger tickets to the member companies. The tickets were printed on $2\frac{1}{4} \times 1\frac{1}{4}$ inch green card of a form familiar to travellers as recently as the 1970s. The tickets were printed and numbered by Edmonson's ticket-issuing

__________ Railway.

RAILWAY CLEARING HOUSE

RETURN of Passengers' Fares Booked at the __________ Station.

Month of __________ 187

Progressive Numbers.				Stations.	Route.	Classes.								Rate.	1st & 2nd Class.	3rd Class.	Parly.	Total.
						Single.				Return.								
From	To	Chil-dren.	Non-Issued.			1.	2.	3.	Parly.	1.	2.	3.	Parly.					

P. 1a.

RAILWAY CLEARING HOUSE

[Coaching Department,]

PASSENGERS.

__________ 187

Dear Sir,

The Passenger Returns for the Month of __________, which were due here on the ________ instant, have not yet been received from the Stations enumerated on the other side. Please cause them to be sent immediately.

Yours truly,

Secretary.

To __________

Stations.	Particulars.

Figure 3.3 Standard forms used in the Railway Clearing House, 1876

Source: Dowden 1877: 11. The original is in the custody of the Public Record Office, Kew (PRO ZLIB4/314).

Note: Two of the several dozen different forms used in the clearing house in 1876. 'Form P.1.' was used by the railway companies to compile monthly abstracts of ticket sales from each booking office. 'Form P.1a.' was used by the clearing house Ticket Section to elicit explanations of failure to reconcile tickets collected with the abstracts of tickets sold.

machine – which was probably the only significant mechanization in the entire clearing house. Tickets were issued for each individual booking office in the system, pre-printed for all the common destinations. Tickets were supplied to booking offices in lots of a hundred, each lot serially numbered and continuing from the previous batch of tickets supplied. Thus in every booking office in the land there were little green piles of tickets carefully arranged waiting to be sold. Tickets were sold in strictly ascending serial order. At the end of the day, the booking-office clerk would record the serial numbers of the lowest-numbered unsold tickets and send them to the company's head office with the cash received that day. At the head office this information was used to check the cash received and to compile a monthly summary of ticket sales and receipts for the Railway Clearing House (Figure 3.3).

The second input to the clearing system was the tickets collected from passengers at the end of their journey. This was an integral part of the process and was conducted with some vigilance, because a lost ticket meant a delay in receiving payment from the clearing house. It was the responsibility of the railway companies to sort the tickets by destination, tie them up with string into little bundles, and send them to the Railway Clearing House once a month with the summaries of ticket sales.

Thus, once a month a fresh wave of tickets and monthly summaries swept into the Coaching Department of the clearing house. In 1876, there were approximately 3.3 million tickets processed – an average of a quarter of a million tickets per month. In the 25-strong Ticket Section, the boy clerks would arrange the incoming tickets into serial-number sequence and reconcile them with the monthly returns. It was in dealing with the exceptions that the experience of the senior clerks would be called into play. A typical problem might be a missing half-fare ticket for a child. (The tickets were physically cut in half and the unsold portion was required to be returned unused to the clearing house for credit.) But there were a hundred other reasons for a discrepancy between the tickets collected and the monthly returns. In all cases, a standard form would be completed and sent to the offending company inviting an explanation (Figure 3.3). Another task of the clerks in the Ticket Section was to identify the actual route taken by the passenger, where different routes were possible. This could be determined by the way in which the ticket had been punched by the train conductor – each railway having its characteristic 'nippers'. Eventually all the tickets that had been verified by the Ticket Section would be tabulated on

another standard form and passed on to the appropriate Passenger Section.

In the Passenger Section, the proceeds of each individual ticket sale would now be divided up between the participating companies, in accordance with the appropriate fare structures. For example, an 'ordinary' fare was defined as the sum of the local fares for the individual legs making up the whole journey, and was divided accordingly. But for tourist traffic and special low fares, a division was normally made in proportion to the total mileage travelled on each company's line – and this was determined from a set of distance tables that gave the mileage between all of the junctions in the railway network. In other cases, some special tariff that had been agreed between the companies was used.

For each passenger ticket in the system, the company that sold it became the 'debtor' and the other companies became the 'creditors' for this particular transaction. As the tickets for an entire month were processed, thousands and tens of thousands of debits and credits would be accumulated against the name of each of the 80 companies in the system. Finally, after a couple of weeks' activity, all the month's tickets would have been processed, and it was now possible to total up all the debits and credits and arrive at a single transfer of funds between each company and the clearing house. The aggregate of these financial transfers had to balance exactly. Failure to achieve a balance led to an awesome audit trail. For this reason, clerks worked in pairs, constantly checking each other's work.

There were no statistics compiled by the clearing house for the transaction-cost per ticket, which would be the prime operational measure in today's information-processing environment. However, it is possible to make an informed estimate. In 1876 the total revenue processed by the clearing house was £15.9 million, and the cost of the clearing house operation was about 1 per cent of this – say £160,000. The 3.3 million through-passenger journeys represented 18.8 per cent, or £3.0 million, of this total. Hence, for an average ticket price of 18s 2d the transaction cost was 2¼d. The 165 Passenger Section clerks would have processed an average of 10 passenger-transactions per hour. The clerks' salary probably accounted for a half of the total of 2¼d per transaction – the remainder being taken up by the contribution of the Mileage and Demurrage Department (see later), the Ticket Section, and printing and office overheads. This figure compares quite favourably with other large-scale clerical operations of the time. (The Post Office Savings Bank, for example,

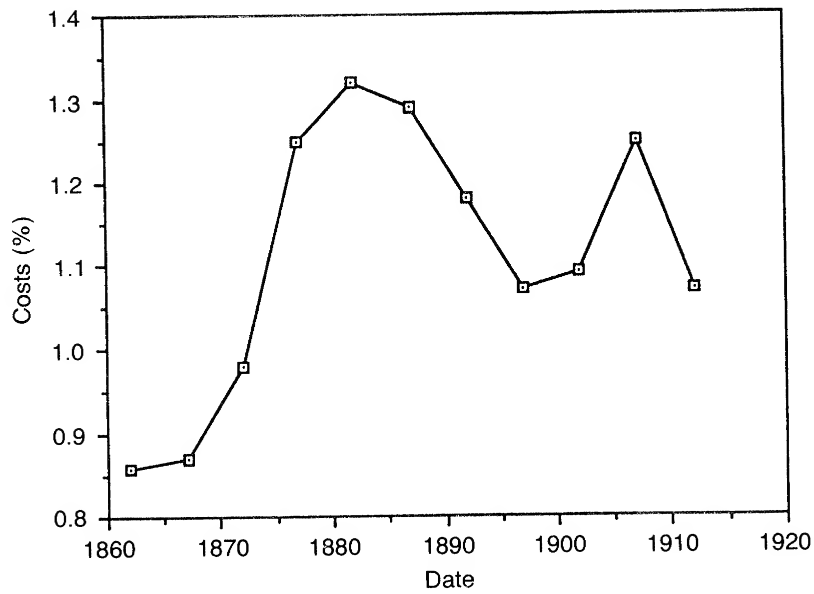

Figure 3.4 Railway Clearing House costs, 1864–1914

had a transaction cost of 7d for each movement on a savings account (Scudamore 1873).)

Throughout the life of the Railway Clearing House there was a constant tendency for costs, as a proportion of total settlements, to rise from its nominal level of about 1 per cent (Figure 3.4). The main reason for this was the falling cost of rail services: for example, in the twenty years between 1874 and 1894, the average cost of a through-passenger ticket fell from 19s 5d to 12s 8d. The tendency towards increasing costs was counteracted by occasional organizational reforms. The main type of reform was to externalize and eliminate some of the simpler data-processing tasks. For example, by 1876 passenger-traffic settlements which involved only two companies had been taken out of the system altogether. In this way companies were forced to make their own private and relatively simple revenue-sharing agreements, leaving the clearing house to deal with the more complex multi-company passenger traffic. In 1890, tickets involving three companies were taken out of the system.

The Mileage and Demurrage Department

The primary function of the Mileage and Demurrage (M&D) Department was to enable the rolling stock of the participating companies to be pooled in a way that compensated those operators who put rolling stock into the system, charged those who used 'foreign' rolling stock, and encouraged the prompt return of vehicles to the original owner. This was an extraordinary undertaking, given that the total rolling stock owned by the railway companies at this time was in the region of a quarter of a million vehicles – locomotives, carriages, trucks, wagons, etc.

The basis of the data-processing operation was a unique serial number which was given to every item of rolling stock in the railway system. When a goods train was made up, a card was fixed to the side of each vehicle in the train showing the serial number; the name of the owning company; the destination; and the contents. As the train moved around the country, picking up and dropping off wagons, its movements could be monitored in the clearing house. There were two inputs to the system: the weekly returns of the number-takers, and the weekly returns of the railway companies.

At each junction between two railway companies a number-taker was employed to record for the clearing house the destination of each train passing through, and the details of every one of the average 30 vehicles that made up the train. The number-taker must have had one of the most unappealing and dangerous jobs in existence. In 1892, a *Times* reporter described the lot of this body of men:

> Night and day throughout the year they are engaged in recording the number, name and owner, and intended destination of every railway company's waggon, passenger carriage, van, or tarpaulin which passes from one company into the hands of another company, the same process being gone through when the vehicle or sheet is returned. The making of this record is unquestionably one of the most arduous as well as one of the most important duties in connection with the system. The number-takers must be capable of bearing exposure to all kinds of hard weather, and possess the requisite amount of smartness and intelligence to enable them to perform their different duties with the utmost accuracy and dispatch. It is to them in great measure that the efficiency of the Clearing House is due.
>
> (Anon: 1892)

Apart from the health hazards of exposure to bad weather, the number-taker was often at his busiest in the night shift, which produced additional dangers:

> Shunting yards were often ill lit or without any form of lighting, so that extra care was needed to avoid tripping over exposed points, cables or rods. The greatest danger was being crushed between the buffers or run down when crossing the rails to inspect waggons.
>
> (Bagwell 1968: 175)

The number-taker recorded the information he collected in 'his small blue book' using a pencil, and in the intervals between trains he would copy the details out carefully on to a weekly abstract for the clearing house. The number-taker recorded traffic movement at *junctions*. To supplement this information, the railway companies were also required to send in a weekly return of all foreign vehicles passing through the *stations* on its lines. This was the second input to the M&D department.

These two sources of information enabled the 276 clerks in the M&D Department to build up a detailed picture of every item of rolling stock under its control. One or more 'account clerks' were assigned to the account of each railway company that had put rolling stock into the system. It was the responsibility of the account clerk to track all the vehicles for 'his' company, and debit the companies that used them.

A vehicle only became known to the clearing system, and therefore chargeable to another company, when it had left its parent line. Hence its entry into the system would be detected when it appeared in one of the weekly abstracts of a number-taker at the junction between one company and another. Once the clerk had detected this event, he would create a movement record for the vehicle on a 'Waste Sheet' – a large, decimo-sized form ruled into vertical columns – using a peculiar shorthand notation (Figure 3.5). Once the original entry for the vehicle had been made on the Waste Sheet, it had to be tracked through the system until it returned to its parent line. This involved searching through dozens of weekly abstracts, and needed a deep knowledge of the railway network. An important function of the clerk – which he only acquired through long experience – was to detect when a vehicle had been attached to the wrong train. Hence, the M&D clerk had one of the few jobs in the Railway Clearing House that was not completely mechanical. Although Victorian data processing was highly routinized and a clerk

✓ 4120	Means that the running of the vehicle from the time of leaving its owner's line to return thereto has been duly noted.
✗ 4120	Signifies demurrage has been charged to the respective companies.
4120	Tells that the vehicle or sheet went through to further station, and was not unloaded.
✗ 4120	Signifies that the car was light loaded, and was not subject to mileage charge.

Figure 3.5 Coding system used for mileage and demurrage in the Railway Clearing House

Source: McDermott 1890: 32. The original is in the custody of the Public Record Office, Kew (PRO ZLIB4/327).

Note: The number 4120 is the vehicle's unique serial number. The dots above the number indicate the number of days taken for the outward journey; the dots below indicate the number of days for the return journey. A tick indicates that mileage charges have been made; a crossed tick indicates that both mileage and demurrage charges have been made. An underscore indicates that the wagon has a tarpaulin. Circling indicates that the vehicle is empty and should not incur a mileage charge.

was often reduced to an automaton this was done for efficiency, and not out of principle; where the human faculties of a clerk could be put to good use – as in the M&D department – they often were.

Once a month, the Waste Sheets for a company were 'sewn together under cover of brown paper' ready for the final financial settlement (Dowden 1877: 99). At this stage the Waste Book merely recorded the movement of vehicles. Thus a large fraction of the account clerk's time was now spent making the detailed calculations for mileage and demurrage charges. *Mileage* was the charge made for the use of a vehicle over the lines of another company. This was computed from the distance travelled, according to a tariff for each different type of vehicle. The mileage charges provided the economic

incentive for railway companies to put rolling stock into the common user pool. The investment decisions of individual companies were made on the basis of their own use of a vehicle and the anticipated mileage charges accruing from other companies. The *demurrage* charges provided the financial discipline for the common user system not to be abused by unscrupulous companies. Once a vehicle had passed into the province of a 'foreign' railway company it was allowed only a fixed period to make its journey (one day for journeys up to 120 miles, two days for journeys up to 250 miles, and three days thereafter). A journey taking longer than these times incurred a demurrage charge. Demurrage charges were also made for empty wagons – which provided a powerful incentive to reuse vehicles quickly or return them to the owner.

The job of the M&D clerk was a very demanding one. In 1876, on average a clerk recorded 36,000 Waste Book entries in a three-month period. This would represent an average compilation rate of at least one entry per minute; not including the computation of the mileage and demurrage charges to the debtor companies. Even so, the M&D clerk probably had the least uninteresting drudgery in the clearing house.

FOSSILIZATION AND MECHANIZATION

All of the early British large-scale offices showed a tendency to fossilize quite early in their lives. The office-machine revolution that swept across the United States in the 1880s and 1890s largely passed by British offices leaving them unaffected. The main reason for this is the early-start phenomenon: it was very difficult to reorganize the working practices of an office that had been in existence for a generation, and where the office routine had achieved a degree of perfection over which the early office machines could make only an incremental improvement. For example, a Burroughs adding machine would have represented a significant capital investment (the equivalent of a half-year's salary of a clerk) but would have made only a marginal improvement to the accuracy and output of a well-trained clerk. Another brake to mechanization was the fact that the information system had come to rely on well-trained and experienced clerks who in many cases operated at a level that was more than purely mechanical, making office automation a non-trivial task. Unfortunately, these attitudes persisted long after lower costs and improved reliability of office machinery in the early 1900s had made the case for office mechanization overwhelming.

The Railway Clearing House was extraordinarily slow to mechanize, even by the standards prevailing in British organizations of the period. As late as 1911 there appear to have been no calculating machines and only two typewriters in the entire organization (RCH 1920–30). And by the outbreak of the First World War in 1914, the sum total of advanced office appliances appears to have been three typewriters, four Burroughs accounting machines and five Comptometers. This for a clerical staff of approximately 3,000 men, women and boys. The start of hostilities produced wholesale disruption in the clearing house which effectively put and end to any thought of mechanization until the 1920s.

Immediately following the declaration of war on 4 August 1914, the British railway network was taken over in the national interest under the unified control of the Railway Executive Committee of the Board of Trade. Since the *raison d'être* of the clearing house had been the division of revenues between the competing railway companies, much of the work of the clearing house was no longer needed. For example, it was immediately decided to introduce a 'common user system' by which the entire rolling stock of all the companies was pooled and mutually owned. Thus mileage and demurrage records were no longer needed, which freed a large number of clerks to enter the fighting forces. The number-takers and a small corps of clerks were kept on, however, to maintain the records of the movement of vehicles to keep operational control of the system. The payment of passenger- and goods-traffic receipts between the operating companies was also suspended, freeing another body of clerks. In July 1915 a prepayment system for parcels traffic (using stamps) was introduced and another body of clerical work was eliminated. Approximately half of the entire clerical labour force was eliminated during 1914–15 leaving a total workforce of something over 1,400 people.

With the armistice in 1918, there should have come an opportune moment to undertake a rationalization of office methods. But the clearing house appears to have been overtaken by events – first, there was a moral obligation to re-employ clerks returning from the fighting forces; and then there was an urgent need for statistical work prior to the government-directed amalgamation of the railways in 1923. For example, in October 1919 almost 700 demobilized clerks were sent to work producing ton-mile and other statistics for the newly-formed Ministry of Transport, using manual methods that had barely changed in 50 years. By 1920 the clearing-house staff was back up to 2,443 clerks, and by 1921 an all-time high of 3,423 was reached.

In 1920 the burning topic of office mechanization began to infiltrate even the deep recesses of the Railway Clearing House. In October 1920 an Office Appliances Committee was established with two main terms of reference. First, to ensure that its existing office equipment was being put to good use. (This was apparently stated without irony – in spite of the fact that, apart from a solitary Hollerith Tabulator used for ton-mile statistics, the entire inventory of office machinery amounted to just 16 typewriters and 15 calculating machines.) The second term of reference was to see how office machinery could be used to improve efficiency.

The Office Appliances Committee remained in force for at least ten years. Although the clearing-house secretariat did its usual job of damping out any spark of life in the recorded minutes, one can sense the tensions between the die-hard traditionalists and a rising generation of office mechanizers. Thus in the first meeting we find a stalwart of the Merchandise Department protesting there were no operations that could be mechanized 'with any appreciable saving in either time or labour'.

There and everywhere else, the Office Appliances Committee uncovered practices that were positively Dickensian. For example, in the Secretarial Department the entire staff records – for 3,400 staff – were still kept in bound ledgers. The committee recommended implementing a card-based system. Similarly, they discovered that correspondence was still being filed in very expensive hard-bound books of a pattern that must have been introduced half a century earlier. It was recommended that carbon paper and flimsies should be adopted.

But these were minor inefficiencies compared with the practices in some of the big departments of the clearing house. To take one example, a report was presented on the case for mechanizing the calculation of local ton-mile statistics. It was argued that six female Comptometer operators would be able to take on the work of 70 male clerks, and the following cost-benefit analysis was given:

	£ per annum
70 male clerks @ £272 p.a.	£19,040
6 Comptometers @ £100 16s 0d each (amortized over 10 years at 5%)	£ 78
6 female Comptometer operators @ £156 p.a.	£ 936
Net saving	£18,026

One feels that in a less moribund organization the fact that the opportunity of saving £18,000 a year for a one-time outlay of £600

had not been taken ten or twenty years previously would have been a cause for concern. But there are many examples like it in the minutes of the Office Appliances Committee, and none of them elicits any comment whatever. Far from it, the acquisition of office machines did not gather any momentum at all until 1923 and 1924, and it was only in 1925 that the clearing-house staff fell to below 3,000 for the first time since 1921. Although office machinery must have played a part in this decline, recession and the simplification of operations due to the amalgamation of the railway companies were probably greater factors. An inventory of 1930 still only recorded a total complement of 64 typewriters, 73 calculating machines, and a sprinkling of duplicators and other office appliances (RCH 1920–30). This was an improvement over ten years previously, but with one office appliance for every ten or twenty members of clerical staff, it was still a tenth of that in best-practice offices.

THE RAILWAY CLEARING HOUSE AND THE MATURING OF BRITISH ENTERPRISE

The story of fossilization and lack of mechanization told in the previous section is repeated in nearly all of the large British offices – the General Register Office and the Census Office, the Post Office Savings Bank, the clearing banks, the industrial assurance companies, and so on. This failure to adopt office machinery has obvious parallels with the slowness of the manufacturing industries to take up new production technology in the same period (e.g. Elbaum 1986).

However, a less obvious consequence of the Railway Clearing House was that, despite its technical inefficiencies, it was sufficiently successful in institutional terms to provide an alternative to the formation of large national operators. The Railway Clearing House was a classic British compromise between the extremes of *laissez-faire* competition and nationalization. This was fully appreciated even in the 1890s:

> For all practical purposes, and so far as the public interest is concerned, all this aggregate of machinery of locomotion exists as the property of one company. State ownership of the railways could not be more effective and comprehensive than that which exists at the present time with regard to the railways of the United Kingdom. . . . The seemingly incongruous task of uniting combination with competition is accomplished by the agency of the Clearing House and as a result we have . . . a railway service unequalled by that of any country in the world.
>
> (McDermott 1890: 22–3).

In the United States there was no equivalent of the Railway Clearing House. Hence the American railways responded to the through-traffic problem by amalgamating the many small railroads of the 1850s and 1860s into a much smaller number of large railroads; and then by forming cartels in the 1870s to deal with long-distance through traffic. These cartels were not particularly successful because of administrative and data-processing, but primarily legal, problems. This breakdown led directly in the 1880s to the great system-building period, which resulted in the formation of vast multi-divisional railroads such as the Pennsylvania – with its staggering 110,000 employees and a railroad network extending nearly 8,000 miles.

In order to control these massive undertakings, Chandler has argued (1977: 204–5, 1990: 253) that the 'railroad was in every way the pioneer in modern business administration' and that for the United States they 'provided training in modern large-scale administration'. Because of the smaller scale of the British railways compared with those in the United States 'British railroad managers were less challenged to pioneer new methods of organization and internal control' and 'therefore, did not provide models for industrial management as did the U.S. railways. Indeed, by the end of the century British railroad managers were traveling to the United States to learn American management methods.'

Paradoxically, in the 1930s it was argued by leading transport economists such as K. G. Fenelon (1932: 92) and C. E. R. Sherrington (1937, vol. 1: 293) that the Railway Clearing House had 'facilitated the process of railway amalgamation'. In fact, precisely the opposite was true: while the clearing house may have helped smooth the practical details of amalgamation in 1923, its existence had allowed to be put off for half a century the ultimate necessity of a small number of national operators. It was only after the 1923 reorganization which resulted in four national railway companies that some of them adopted a multi-divisional administrative structure. And then the administrative models plainly came from the United States. (The Great Western Railway, for example, even adopted such nomenclature, as 'President' and 'Vice-President' which was otherwise wholly foreign to British companies (Sherrington 1937, vol. 2: 12–27).)

It remains an open question as to whether or not the existence of the railroad model was the critical factor in the development of large-scale enterprise in the United States; nor do we know the relative importance of cultural, economic and geographic factors. But it is safe to assert that the railroad model was a *major* factor and that

British industry never had the benefit of it. This must have had significant impact on the maturing of British enterprise, to put it no more strongly.

NOTES

1 I am most grateful to Philip S. Bagwell, the leading expert on the Railway Clearing House, who provided valuable criticism of an early draft of this paper. I am also grateful for the spirited comments and criticisms from several participants of the Conference on 'Global Perspectives on Business Information', which resulted in a number of improvements to the paper.

BIBLIOGRAPHY

Anderson, G. (1976) *Victorian Clerks*, Manchester: Manchester University Press.

Anon. (1864) 'Our railway network', *Cassell's Illustrated Family Paper*, 8 October: 316–18.

—— (1892) 'The Railway Clearing House', *The Times*, 21 January: 8.

Bagwell, P. S. (1968) *The Railway Clearing House*, London: Allen & Unwin.

Beniger, J. R. (1986) *The Control Revolution*, Cambridge, MA and London: Harvard University Press.

Chandler, A. D. Jr (1977) *The Visible Hand: The Managerial Revolution in American Business*, Cambridge, MA and London: Harvard University Press.

—— (1990) *Scale and Scope: The Dynamics of Industrial Capitalism*, Cambridge, MA and London: Harvard University Press.

Dowden, T. F. (1877) *The Railway Clearing System as Practised in the English Clearing House in 1876*, London: Stationery Office.

Elbaum, B. (1986) 'The steel industry before World War I', in B. Elbaum and W. Lazonick (eds), *The Decline of the British Economy*, Oxford: Oxford University Press.

Fenelon, K. G. (1932) *Railway Economics*, London.

Fulford, R. (1953) *Glyn's 1753–1953*, London: Macmillan.

Giuliano, V. E. (1982) 'The mechanization of office work', *Scientific American*, September: 125–34; repr. in T. Forester (ed.), *The Information Technology Revolution*, Oxford: Basil Blackwell, 1986.

House of Commons (1841) 'Second Report from the Select Committee on Banks of Issue', *Parliamentary Papers* [410]V.

Lardner, D. (1850) *Railway Economy*, London: Taylor, Walton and Maberly.

McDermott, E. (1890) *The Railway Clearing House: Its Place in Relation to the Working and Management of English Railways*, London: Railway News, and New York: Poors.

Machlup, F. (1962) *The Production and Distribution of Knowledge in the United States*, Princeton: Princeton University Press.

McLaughlin, J. F. and Birinyi, A. E. (1980) *Mapping the Information Business*, Cambridge MA: Report of the Program on Information Resources Policy, Harvard University.

Morison, K. (1846) *The Origins and Results of the Railway Clearing House . . . in the Year 1845*, London: Smith and Ebbs.

Porat, M. U. (1977) *The Information Economy: Definition and Measurement*, Washington DC: US Dept of Commerce, Office of Telecommunications.

RCH (1920–30) *Office Appliances Committee*, RAIL 1080/574, Public Records Office.

Scudamore, F. I. (1873) *Memorandum [on the Post Office Savings Bank]*, POST 75/4, Post Office Archives.

Sherrington, C. E. R. (1937) *The Economics of Rail Transport in Great Britain*, 2nd edn, 2 vols., London: Arnold.

Turnbull, G. L. (1979) *Traffic and Transport: An Economic History of Pickfords*, London: Allen & Unwin.

Yates, J. (1989) *Control through Communication*, Baltimore and London: Johns Hopkins University Press.

75 - 97

4 The development of an informational infrastructure in Meiji Japan[1]

Kaoru Sugihara

L52

D83

L46

I

This chapter traces the development of state-initiated information-gathering machinery during the process of Japan's industrialization, and argues for its critical importance. This proposition has at least four implications for the current historiography. First, it calls for a reappraisal of state initiatives in a non-Eurocentric perspective, focusing upon its provision of commercial and technical information for local merchants and manufacturers engaged in the marketing and production of modern Asian (Japanese and Asian international) manufactured goods rather than its role in the introduction of western technology and organizations to Japan. The state participated in the market and product-forming processes in addition to taking standard measures for technology transfer and infant industry protection. Second, the resulting close relationships between government and business reflected the specific need to create a set of modern Asian manufactured goods, different from both traditional Asian artefacts and western manufactured goods. The establishment of a large-scale information-gathering machinery made sense, because Asia's integration into the world economy raised the level of purchasing power of the Asian population around this time, and their consumption patterns were based on the Asian material culture centred around such commodities as rice, cotton, silk, sugar and tea. Since Japan was part of this Asian civilization, there was a real chance for Japan to compete with western powers for the production of rice wine or cotton cloth to suit their taste.

Third, local governments played an important role in this process. The local government often picked up indigenous business initiatives and passed them on to the central government, which eventually led to product innovation, while the central government was usually

responsible for channelling this information to the relevant people and getting necessary feedback. The critical factor here was not so much the strength of nationalism as the state's manoeuvring of the balance and articulation between national and local economic interests. The heritage from the Tokugawa period (1603–1868), relatively undisturbed by the introduction of a western-style political system and organizations, appears to have featured here. Fourth, in the context of evaluating the relevance of the Japanese experience to the general understanding of economic development, a study of how the market and appropriate technology were identified is particularly important because such an intensive effort has not been observed elsewhere. The more traditional explanations for Japanese industrialization do not sufficiently differentiate Japan from other countries: there was little difference with other Asian countries in terms of the availability of cheap labour; the state's direct involvement in the promotion of heavy industry was not large, and, where important, the result was rather similar to the experiences of Russia or post-war India and China.

This chapter concerns the Meiji period (1868–1912), and concentrates on the years after the Matsukata deflation (1881–4). The next section outlines the development of the Meiji industrial policy with special reference to the role of local trade associations. The third section traces the development of a network of key institutions and the ways in which local merchants and manufacturers were linked through local trade associations to national and international information-gathering machinery. The last section suggests some of the wider implications of the subject of this chapter.

II

The role of the state in Meiji economic development has traditionally been discussed in terms of its reactive response to the western political and economic encroachment. Although by no means politically fully united or well informed of the West at the outset, the new state did manage to create a strong central government with a commitment to 'enrich the nation and strengthen the army'. A comprehensive programme for the introduction of western technology and organizations, with a nation-building ideology giving priority to the military capacity, was pursued, broadly in accordance with the Gerschenkronian model (Gerschenkron 1962; Rosovsky 1966: 91–139) at least until the Matsukata Deflation (1881–4) forced the government to sharply reduce its expenditure.

Almost from the very beginning, however, the government had an equally, if not more, important task of creating an institutional framework for domestic market expansion. In 1881 to 1885, 70.8 per cent of the population were engaged in agriculture, while 29.2 per cent were engaged in the industrial sector. The latter consisted of a large traditional sector (27.5 per cent) and a small modern sector (1.8 per cent). These proportions shifted only slightly during the Meiji industrialization. In 1911 to 1915, the respective figures were 60.7 per cent in agriculture; 31.7 per cent in traditional industry; and 7.6 per cent in modern industry. The size of traditional industry in absolute employment terms was much more important than that of modern industry. The output figures for traditional industry are not available, but cottage-industry production (defined as production with employment of less than five persons) consisted of 51.1 per cent of total industrial production as late as 1909, and continued to grow in absolute terms (Nakamura 1983: 28, 80).

Yet the growth of this traditional sector was not achieved easily. The Meiji government decided to abandon feudal restrictions for economic activities almost immediately after the Restoration of 1868. It advocated the freedom of enterprise, denied the privilege and monopoly enjoyed by merchant guilds, and attempted, in particular, to dissolve those guilds with restrictions of membership, the power to control or manoeuvre prices, or high charges for membership entry. Thus by 1873–4 most of the guilds were either dissolved or effectively made powerless. The result of this new policy was the development of chaotic market conditions, with a flood of products of an inferior quality aimed for quick profits; totally unregulated merchant activities with elements of fraud and cheating; and a number of bankruptcies and sad stories of lost fortunes. Particularly severely hit were those traditional industries which had been heavily protected under the Tokugawa regime, including silk manufacture, cotton manufacture, metalware, pottery, lacquerware, and timber and bamboo products. Thus one of the most urgent aims of the new government was to create a system of regulated competition, different from both feudal restrictions and unregulated free competition, and restore and modernize these industries (Yui 1964: 8–10).

It was with this in mind that Maeda Masana, an official of the Ministry of Agricultural and Commercial Affairs (established in 1881: hereafter MACA), argued for the protection and promotion of traditional industries through the enactment of the Trade Association Act. Although the significance of promoting traditional industry was

recognized by the Meiji leaders as early as 1874, *Kōgyō Iken* (Proposals for Enterprise Promotion), the first systematic economic-policy document compiled by Maeda and published in 1884, was instrumental in shifting the priority firmly from the introduction of modern industries to the promotion of traditional industries (Inukai and Tussing 1967: 51–2). While the former goal required substantial funds to import modern machinery from the West, the latter aim related directly to the immediate task of earning foreign currency. The balance of payments crisis was a major factor behind this policy change.[2] Although part of Maeda's plan concerning the establishment of local banks to provide agriculturalists and industrialists with credit was denied by Finance Minister Matsukata Masayoshi for fiscal reasons and Maeda temporarily left MACA as a result, the main thrust of his plan was effected by the Ministry after 1885.

The new rules for organizing local trade associations were set out in MACA's 'Working Rules of Trade Associations' (*Dōgyō Kumiai Junsoku*), sent to each prefecture in November 1884. The prefecture was to administer local trade associations in order to regulate competition and protect and promote traditional industries. If more than two-thirds of the traders agreed to form an association, it was made compulsory for the rest to join the association, although there was no penalty if they did not follow this guidance. Many trade associations were formed under this rule, but the government was extremely reluctant to abandon the ideal of the freedom of enterprise, and refused to enact an act with penalty clauses. The control of trade through trade associations thus remained ineffective, until the 1892 notice allowed some prefectures to insert penalty clauses, in cases of disobedience. But even this was restricted to those trade associations dealing with key products (Yui 1964: 34–40).

In the meantime, the first wave of industrial promotion initiatives occurred between 1885 and 1889.[3] The number of local exhibitions held rose from 85 in 1884 to 393 in 1888. *Nōshōkō Kōhō*, a monthly journal containing commercial and technical information primarily for the promotion of agriculture and traditional industry published by MACA between 1884 and 1889 had a circulation of 30,000 copies at its height (Y. Tsunoyama 1986: 123–7). MACA gave assistance to local exhibitions by sending judges and offering prizes. It also advised trade associations to set up training schools and experimental and testing stations, and responded to the request for assistance by sending officials and engineers. Between 1885 and 1890 MACA offered guidance to 27 prefectures on the subject of cotton and silk

manufacture, sake brewing, paper making, pottery, porcelain, lacquerware and metalware. The guidance was targeted at small establishments without an extensive use of machinery, and was concentrated on the introduction of the basic standardization techniques for mass production. The usage of imported dye stuff in textiles or mixing techniques of sand in pottery, for example, were taught with considerable success. These initiatives had demonstration effects too: it became increasingly common for the prefecture to provide financial assistance for setting up training schools and showrooms and organizing advisers' regular visits (Yui 1964: 26–32).

The second wave of MACA initiatives came after the victory of the Sino-Japanese War of 1894–5, with a strong inclination towards export drive. Between 1896 and 1898 a series of major conferences (*Nōshōkō Kōtō Kaigi*) were held to implement systematic industrial production and export promotion measures. In addition to consular reports published by the Ministry of Foreign Affairs (hereafter MOFA), MACA introduced a system of sending business trainees overseas (see next section), and set up overseas commercial museums to enhance the capacity to collect relevant market information overseas. The publication of reports by business trainees began in 1897. The number of local exhibitions held rose from 288 in 1890 to 544 in 1895. More significantly, the idea of setting up a more permanent space for exhibiting commercial products with relevant information became prevalent, due partly to the voluntary movement for the improvement of local industry led by Maeda Masana. The number of prefectural- and city-sponsored commercial museums rose from 11 in 1892 to 21 in 1899. MACA established its own commercial museum in 1896, and started publishing its reports in 1898 (see next section). In the meantime, three volumes of *Reference Guide to Key Export Products (Jūyō Yushutsu-hin Yōran)* were published between 1896 and 1898, incorporating consular reports, maritime customs reports, and the local-government reports into a coherent form (Y. Tsunoyama 1986: 129–35).

Perhaps most crucially, two trade-associations acts were finally enacted to monitor the quality of products and effect promotion measures. The Key Export Products Trade Association Act (*Jūyō Yushutsuhin Dōgyō Kumiai-hō*) of 1897 specified that the membership of trade associations be compulsory and that those who disobeyed the association rules be charged penalties. This act was replaced in 1900 by the Key Products Trade Association Act (*Jūyō Bussan Dōgyō Kumiai-hō*) which applied to all major industrial products of Japan. The association included both merchants and

manufacturers, charged membership fees, and specified the procedure of testing the quality of products. However, the test itself was left in the association's own hands, which in many cases lessened the effectiveness of ensuring the testing standards (Yui 1964: 40–1; see also Fujita 1988: 97–105).

Two aspects of this second wave deserve special mention here. One is its transitional nature in terms of target products. On the one hand, export orientation, particularly towards the Asian market, meant the need to continue to focus on the standardization and the mass production of traditional manufactured goods. At the same time, there was an increasing need for mechanization, hence the identification of suitable machinery. Unlike the earlier attempts to introduce western-style modern industry, the main aim here was to invent simple (water- or steam-powered) machinery to suit the needs for local manufacturers. The successful examples included the diffusion of half-wood, half-iron (hence less expensive) powerlooms and steam-powered noodle making machines (Nakaoka *et al.* 1986: 108–33; Makino 1911: 157–68).

The other feature was an increased central control of local-government initiatives. The enactment of these trade association acts and the increased state subsidies to local-government initiatives contributed to this. The local-government budget for industrial promotion increased from 2.5 yen per population of a hundred in 1897 to 8.5 yen in 1902. At the same time, the standardization of policy, export orientation with central-government initiatives, and the increased proportion of central-government subsidies in local-government budgets resulted in the convergence of local activities and their integration into the national information networks (O. Saitō 1984: 236–44).

The third wave followed the Russo-Japanese War of 1904–5 and its immediate post-war recession. By this time some of the main ideas set out in the 1896–8 conferences began to take effect. The orientation towards mechanization became more evident, while the overseas information-gathering machinery also became a prominent feature. The number of commercial museums rose from 31 in 1905 to 36 in 1911, and the coordination by the MACA between local and overseas networks became increasingly systematic and detailed (Sugihara 1990: 245–8). Local commercial museums often had experimental or testing departments by this time. Further measures for technological assistance ranged from regularizing the practice of sending MACA engineers to local commercial museums to establishing vocational schools and industrial experimental and testing stations (see next

section). The local-government budget for industrial promotion mentioned above further increased from 13.1 yen in 1907 to 22.1 yen in 1912, showing a substantial increase in real terms. (The rate of inflation was mild.) The main items of expenditure consisted of the establishment of commercial museums and industrial experimental and testing stations (O. Saitō 1984: 237, 245). The number of patents granted steadily rose from 169 in 1896 to 597 in 1898, and from 1,644 in 1906 to 2,272 in 1911 (Hatsumei Kyōkai 1974: 134).

In this period the coverage of information in MACA publications greatly expanded and their quality substantially improved. Between 1906 and 1909 seven volumes of *Reports on Key Products of Each Prefecture* (*Kaku-fuken Jūyō Shohin Chōsa Hōkoku*) were published, detailing local production statistics, methods of sales, packaging, freight rates, insurance and other costs, and lists of manufacturers and dealers. This was the first systematic attempt to compile the data on the basis of the original surveys conducted by MACA staff. MACA also decided to conduct a series of surveys on key export industrial products in 1905, including their own research overseas. Reference guides incorporating these were published for three years (two volumes in 1908, two volumes in 1909 and three volumes in 1910) (Y. Tsunoyama 1986: 135–48). Among the most informative were the contributions by overseas business trainees many of whom were sent from local trade associations.

A notable feature in this period was an increased diversity in the types of products and the degree of technological development in traditional industry. Some local cotton weavers began to operate factories of medium scale with modern powerlooms, while many wholesale merchants were responsible for expanding local weaving centres by loaning the improved handlooms to rural household weavers (Abe 1990: 186–208). Urban manufacturers began to produce modern mass-produced goods such as matches and brushes for exports, with the use of cheap labour. Wholesalers were instrumental in organizing production here too, which meant that there was no clear demarcation between merchants and manufacturers or between commercial and technical skills (Takeuchi 1991: 169–74). The number of local trade associations reached 770 in 1909, ranging from agriculture to commerce and industry (Yokomae 1911: 195–7). The government was keen to let local centres compete and transfer the best know-how from one centre to another. The commodity-improvement contest was organized annually for this purpose. Overseas market information was sometimes obtained by Japanese merchants, but in many cases the key information was known only

to those Chinese merchants of intra-Asian trade who purchased Japanese goods in Japan. Hence government commercial and technical assistance remained essential. Product cycles were generally short, and export market fluctuations were often great. Yet the total exports of Japanese manufactured goods to other Asian countries increased from £4 million in 1898 to £19 million in 1913 (Sugihara 1980: 58).

In addition to these promotion measures, the central government occasionally intervened in regulating business practices where local trade associations failed to do so. When the demand for silk cloth for exports soared in the 1900s, some manufacturers produced goods of an inferior quality, while others moistened the cloth to increase its weight. These practices were not unknown in the Asian market, where the point of competition centred on cutting the price rather than emphasizing the quality. Further, the government itself was largely responsible for encouraging such a cut-throat competition through export promotion and cross-prefectural exposure to market opportunities. Yet its goal was not to follow existing business practices but to create a market environment suited to modern manufactured goods. In response to a series of complaints from overseas about the quality of Japanese products, the government issued decrees in 1905 and 1906 to control malpractice and make certain technical procedures compulsory, in spite of a strong opposition from liberal economic thinkers. A similar decree was issued in 1905 to make the test at the special station compulsory for the export of straw mats (Yui 1964: 47–8). A critical balance had to be achieved, encouraging the transfer of know-how of successful operations from one prefecture to another as much and as quickly as possible, while retaining and raising the reputation of leading innovators both at home and abroad.[4]

III

The term 'informational infrastructure', as used in this chapter, is inspired by the term 'infrastructure' which usually refers to the physical infrastructure such as railways, ports, roads and sewerage. The postal and telegraphic transmission systems (and later telephone and fax systems) and schools are also often referred to, but usually in the context of social overhead capital. Informational infrastructure is clearly dependent on both the communications systems and the basic education system which enables the public to understand, store and use information. But the term is used here specifically to refer to a

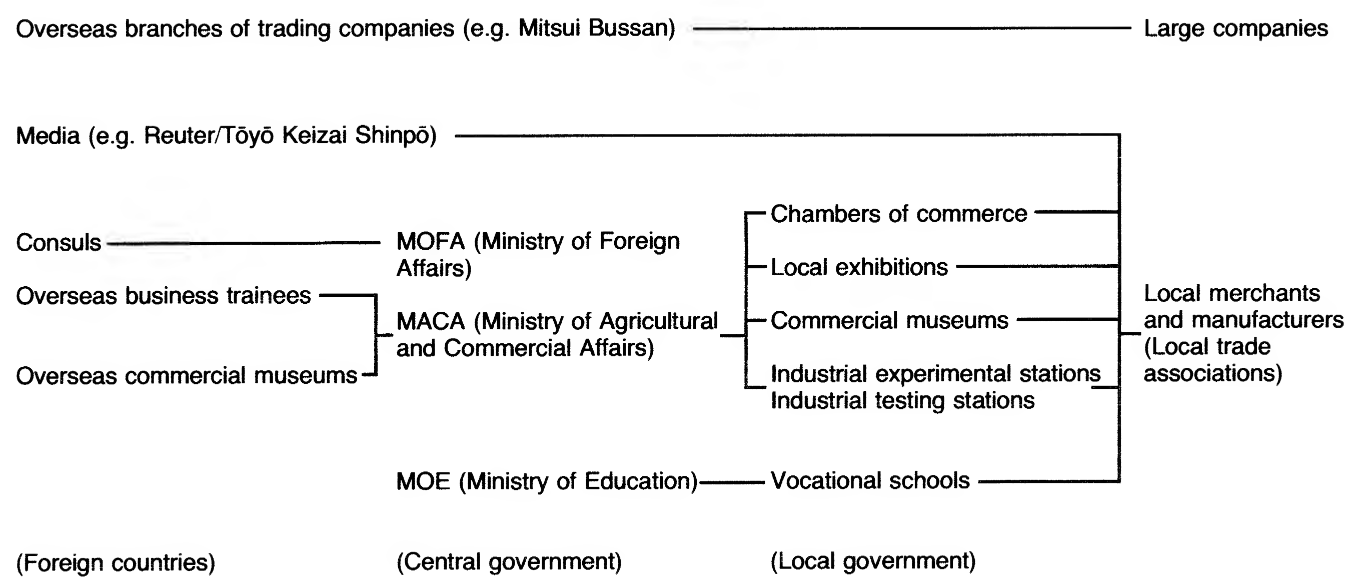

Figure 4.1 Informational infrastructure in Japan around 1910

structure in some public form which provides those in business and the public with various types of economic information in a more proactive way, usually free or with a modest charge. The reason for this focus is twofold. First, it is a common feature of developing countries that the development of communications systems in the physical sense has not been accompanied by the parallel growth of the social capacity to make use of them. Second, the availability of human resources and the stock of knowledge do not guarantee the exploitation of their economic worth unless more proactive efforts are made to channel them into specific business contexts. Hence, in my view, it makes less sense to compile all the elements of the informational infrastructure than to ask the question of how they can be put together into a coherent form. The types of information I have in mind include the latest inventions, freight rates, packaging practices, the price and quality of foreign goods in direct competiton with Japanese products, general economic conditions which would affect demand for Japanese goods, and any relevant cultural and social information on consumer taste for the benefit of future product innovation. They consist of the bulk of business information required, and the element which needs to be kept secret is usually very limited.

In late Meiji Japan this infrastructure existed as a network of local, national and international organizations. Figure 4.1 presents the main lines of information networks, including some private ones. Large enterprises had networks of their own, while media also had its function, particularly in the way of dissemination.[5] But most of them were part of the central or local government, and were non-profit-making organizations, although they were often organized or supported by the local business community, typically local trade associations. It is the activities of these organizations that I refer to as informational infrastructure in this chapter. I shall describe their development below, focusing particularly on consular reports, overseas business trainees, commercial museums, and industrial experimental stations and vocational schools. The chambers of commerce tended to represent relatively large companies and the higher echelons of the local business community, and acted as powerful political lobbies (Miyamoto 1988: 5–25). The department of promotion of enterprises in each prefecture coordinated various activities at the local level.

Consular reports

After the opening of Japanese ports to foreign trade in 1858, most of the Japanese trade was conducted by foreign (Chinese and

western) merchants. The Japanese merchants had little experience of foreign trade, and were at a disadvantage when they negotiated prices and other terms with them in treaty ports. The government was thus keen to promote 'direct export', that is, exports of Japanese products by the Japanese themselves. The early Meiji government participated in overseas exhibitions and translated foreign information into Japanese, but increasingly felt it necessary to collect the kind of economic information Japanese merchants and manufacturers needed by themselves. Thus MOFA opened the first consulate in Shanghai in 1870, and gradually increased the number of consulates to 24 in 1884, 59 in 1900 and 92 in 1911. While much of the work of the consulates in Europe concerned learning about technology and importing manufactured goods and some tasks were designated to honorary consuls, the consulates in Asia were manned with Japanese consuls with the aim of protecting the Japanese business community and regularly sending consular reports home for the benefit of domestic merchants and manufacturers (Takashima 1986a: 72–87). The consular reports were thus a crucial source of information for them in the 1880s and 1890s, and remained the most comprehensive, if not the most informative, source throughout the Meiji period. They were widely circulated and cited in major economic journals and many official publications (S. Tsunoyama 1981: 284–7).[6]

Although the relationship between MOFA and MACA was not always a happy one, their functions were complementary. While consuls had general knowledge of languages and cultures of foreign countries, MACA was in touch with domestic merchants and manufacturers and was likely to better understand the type of information required. Thus overseas information was first collected by MOFA and was passed on to the MACA, which in turn selectively passed it on to prefectures and local trade associations, and eventually it reached local merchants and manufacturers through them.

The workings of this network can be shown by describing how a survey on overseas demand for matches was conducted around 1887 (Sugimoto 1986: 283–305). The export of Japanese matches began in 1877, but a flood of matches of an inferior quality damaged trade, and it did not pick up again until 1886. On 7 September 1887 an Osaka manufacturer Mataki Harutarō (employing about 165 workers in 1886) wrote to MOFA, asking for information on the Hong Kong market. Included in the questions were requests for information about the general market conditions for Japanese matches; their final destinations after re-export from Hong Kong; for lists of dealers and the main categories of matches they dealt with; for information

about the CIF prices, seasonal fluctuations, names of favourite brands; and for lists of imported matches from other countries and their prices. On 20 September MOFA wrote to Minami Teisuke, consul in Hong Kong, who wrote back the result of his investigations to MOFA on 28 October. This was passed on to Mataki on 14 November. MOFA also passed Minami's report to MACA, which responded by asking MOFA to conduct a similar survey in six Chinese treaty ports on 12 December. The results of these surveys were sent from five consulates back to MOFA in January to February 1888. In the meantime the same manufacturer in Osaka requested a similar survey in February 1888, this time covering twelve markets in seven countries. The results were sent back to MOFA in May to August of that year, and, in addition to replying to Osaka through usual routes, they appeared in *Tsūshō Hōkoku* ('Trade Reports'), a journal of about 20 pages published on an approximately weekly basis by MOFA. These reports contained some advice and observations of the future trend. Most of them argued for the need to differentiate the more reputable brands and protect them from imitations, while some warned of the coming competition from the Chinese manufacturers who were in a position to use Japanese matchsticks, western chemicals and cheap labour to produce cheaper matches.

Although the forms and main points of investigations differed industry by industry and over time, essentially the same type of information services were provided through consular reports during the rest of the Meiji period. The significance of this exercise can be compared with the effects of the construction of a railway linking a hinterland village to an overseas market. Like a railway, such an exercise tended to direct the attention of manufacturers to some key markets at the expense of others, just because they were suddenly given access to the information on these markets. For example, it was possible for a Japanese manufacturer to write directly to the importer listed in the consular report. There was no guarantee that taking advantage of these opportunities was the best option for them. On the other hand, without this information network it would not have been possible for this Osaka match manufacturer to compare market opportunities overseas.

Overseas business trainees

As part of the export-promotion measures implemented in the 1896–8 conferences a system of sending business trainees overseas

was established in 1896. MACA asked merchants and manufacturers to recommend young talented men and women to whom MACA would give financial assistance for their training abroad. The length of training was usually two to three years, and their work was supervised by an official at the embassy or the consulate during their stay. Between 1896 and 1913 524 people were sent (134 to Asia; 168 to Europe; 209 to North America). Many were recruited from local trade associations, while some were graduates with specialized knowledge. There was a wide range in the subjects they studied, but the more popular ones included sundries trade (83), textile trade (54), machinery (24) and design (18). The list of overseas business trainees published in 1913 shows their occupation after the completion of their study. Some stayed abroad engaging in trade; some assumed leading positions at industrial experimental stations, technical and design schools and universities; some became MACA officials; many entered big business either as engineers or managers; and many others ran their own business (Nōshōmushō 1913). In short these business trainees played a leading role in the development of Japanese trade and technology as well as its supporting system.

MACA made it compulsory that these trainees would furnish a report. These reports were published first as special reports between 1897 and 1905. They then became a journal *Shōkō Ihō* ('Reports of Commerce and Industry'), after 1905. These reports probably present the best collection of contemporary Japanese knowledge on overseas markets and technology relevant to the modernization of traditional industry. They are also a rich source of first-hand information on the customs and the material culture of peoples in other Asian countries at the time.

The ways in which these trainees contributed to the actual industrial development can be shown by describing the case of the cotton-underwear industry (Sugihara 1984: 70–87). The exports of Japanese cotton underwear began in the early Meiji years, but its dramatic increase occurred between 1898 and 1913. The value of exports to India in particular increased from 82,000 yen in 1898 to 3,344,000 yen in 1913, capturing most of the Indian market by the latter date. Yagi Fukumatsu, an Osaka manufacturer, was among the first to notice the potential of the southeast Asian and south Asian markets. He sent his two employees, Yoshizumi Butarō and Ishida Ryōsuke, to Singapore, Rangoon, Calcutta, Delhi, Bombay, Madras and Colombo, to investigate the nature of demand there in 1901. Yoshizumi then left Yagi to become a MACA overseas business trainee between 1905 and 1907, and joined the special course on

cotton underwear at a textile school in New Bedford, Massachusetts. On his return to Osaka, he started his own business of importing finishing machines for cotton underwear, and lectured on the new technology for the Osaka Underwear Trade Association at the Osaka Commercial Museum. In 1907 when Yagi was asked to make an overseas research trip to India by MACA and the Osaka Prefecture, Yoshizumi accompanied him. Yoshizumi wrote two reports in *Shōkō Ihō* in 1907, one on the cotton-underwear industry generally (a revised version of his lecture at Osaka) and the other on the cotton-underwear market in India (a report of his trip in 1907), and these became the first in-depth government surveys on the subject. Yagi attempted 'direct export' to India, rather than depending on Sassoons and western traders in Kobe, and was one of the three Japanese prize winners at the exhibitions held in 1910–11 in the United Provinces in India.

In 1907 an Indian member of the Legislative Council at the British Government of India pointed out that the rapid influx of Japanese underwear was ruining the Indian cotton-underwear industry and proposed protection measures. Pressed by the public opinion, the Government of India began to suspect that the Japanese Government might be subsidizing the trade, and asked A. R. Firth, British consul in Osaka, to investigate the reasons for Japanese competitiveness. Firth confirmed that the Japanese firms were able to sell their products in India more cheaply than their Indian counterparts in the Indian market, despite the fact that they used Indian raw cotton and paid transportation costs both ways and an import duty of 3.5 per cent, but denied the presence of government subsidies. He however pointed out that, in addition to the combination of superior technology and cheap labour, there were two specific factors accounting for this Japanese competitiveness. One was that the cost of machinery was much cheaper in Japan, because by that time cheaper Japanese machines, modelled after American machines, were made available. While expensive American machines were used for high quality products, mainly for the Chinese market, the Japanese machines were used to produce a lower range exported to India. The second point Firth made was the close attention paid by the government to business practices, constantly providing information and monitoring the standard.

It is difficult to specify the contributions Yoshizumi made to this process, and the extent to which the overseas business-trainee system was responsible for them. What is clear, however, is that the idea of making a cheaper machine in Japan specially for exports of

cotton-underwear to India emerged in a small circle around Yoshizumi, and that it was a crucial factor for the success of this industry.

Commercial museums

Although the Japanese information-gathering machinery was heavily dependent on written documents, the government was also keenly aware of the advantage of seeing and comparing actual products. This was the point of holding exhibitions, but there were other, more permanent ways of using samples for the transfer of commercial and technical know-how. For example, more than 150 samples of Japanese products were sent to Japanese consulates overseas between 1884 and 1890, and consuls were asked to get the responses of potential customers. They reported on the market potential of each sample and the points of improvements. At the same time, a number of foreign goods were purchased by consuls, and were sent home as exhibits. This led to the establishment of modern commercial museums, first in Osaka in 1890, and gradually in most prefectures. MOFA proposed to set up a commercial museum in 1886, but, due to the intra-ministerial conflicts and the difficulty of collecting capital, a commercial museum for the central government was not set up until 1896 by MACA (Sugihara 1990: 244–5). The idea of setting up a commercial museum came from continental Europe, in particular from Antwerp, where such a museum had been established in 1882 (Sugihara 1982; Takashima 1986b: 155–78). After major exhibitions were held, some of the exhibits were displayed on a permanent basis. The functions of the modern commercial museum usually included (1) direct assistance to commercial activities, including the sale of products on behalf of suppliers, the introduction of suppliers to potential buyers, and the organization of exhibitions; (2) the collection and dissemination of commercial information such as a list of suppliers and buyers and overseas information, the publication of such information, and the provision of the latest periodicals such as the reports of other commercial museums and consular reports; and (3) research and advice on technology, design and patents.

Although some local *daimyō* (domainal lords) and prefectural governors exhibited their own produce as part of their industrial promotion programme in the earlier period, the Osaka Commercial Museum was the first to carry all of these modern functions. It exhibited domestic and foreign produce, and had rooms for model packaging techniques, modern advertising methods and chemical analysis. A monthly journal, *Osaka Shōhin Chinretsusho Hōkoku*

('The Report of the Osaka Commercial Museum') started in 1890, carrying extracts of consular reports and a list of overseas products collected and sent by consuls abroad. The museum staff went around local business gatherings and commercial museums in other prefectures and gave technical advice and conducted scientific research.

The MACA Museum was opened in 1896, but it was after the Russo-Japanese War that it took over the role of a national centre from the Osaka Museum. By then it had about 40,000 regular exhibits and over 40,000 visitors a year. By 1905 the majority of prefectures had at least one local-government funded commercial museum, and the MACA Museum held an annual conference for the heads of commercial museums in Tokyo. A typical local commercial museum had departments of (1) exhibits and sale; (2) research (and library); (3) laboratory; and (4) design. Updating information on the latest patents was an important part of their work. The MACA Museum created a regular system of sending overseas exhibits to these local museums. There was a very large number of visitors to these museums, mostly from secondary and vocational schools.

In 1909 the MACA Museum decided to hold an annual commodity-improvement contest to encourage product innovation. It was to select an area where the need for technological improvements was particularly acute, and identify the merits of various domestic products as well as advising further points of improvement by comparing them with foreign goods in competition. The first contest was held in 1910 on toys, and *Nōshōmushō Shōhin Chinretsukan Hōkoku* ('Reports of the MACA Museum') contained domestic and overseas information on the toy market. The winners of the first three prizes were given a high profile. Such exercises no doubt enhanced the reputation of prize winners in a market place, but it also encouraged the imitation of the superior features of these products by other manufacturers. The expected result was a tendency for standardization and technological diffusion through competition.

Industrial experimental stations and vocational schools

Around the turn of the century MACA began to implement a more systematic policy for the accumulation of technical information. A system for regularly sending engineers to local industries was established in 1904, and local governments responded to this by creating full-time posts for technical assistance around this time. Also, a subsidy of up to half of the cost of purchasing machinery was offered to local export industries after 1905. This made possible the

installation of powerlooms for local silk-manufacture industry, for example.

Two more proactive measures taken around this time should be mentioned. First, central and local industrial experimental stations were set up to modernize technology.[7] The central station was set up in 1900, and 13 local government stations were set up between 1901 and 1905: 10 for textiles, 1 each for pottery, fertilizer and machine tools. The local experimental stations concentrated on the practical improvements of machinery in operation. Fukui and Fukushima stations were particularly successful in singling out the best small powerlooms made in Japan through comparative experiments on inventions (Yui 1964: 46–7). The results of these comparative experiments were judged by the stations. The point of government intervention was to offer financial and technical assistance and publicly endorse the selection of the most suitable machinery. It is arguable that intervention of this kind led to the artificial acceleration of technological standardization as well as diffusion, skipping a more natural technology-selection process through market forces. On the other hand, an opportunity for one's invention being readily examined at an industrial experimental station was a major incentive for local inventors. The dramatic increase in the number of applications for patents was evidence of their enthusiasm.[8] The second and related measure concerned the assistance to vocational schools. Here MACA's contributions were relatively limited and were supplementary to the supervisory role of the Ministry of Education. Many locally initiated schools (*Kōshūsho*) were given the status of apprentice school by the Ministry of Education, and with the enactment of the Government Subsidy for Vocational Education Act in 1894, the number of apprentice schools increased from 4 in 1894 to 108 in 1911. The majority of them were located at the centres of traditional industry. Some of the notable examples included the Aizu Lacquerware Apprentice School, the Seto Ceramics School, the Beppu Technical Apprentice School and the Minami-Tsuru Dyeing and Weaving School. The last school, established in 1896 in a traditional centre for silk-fabric production in Yamanashi Prefecture, benefited from the founder's enthusiasm and the key teacher's established reputation and social background, and became the best-known school in the field. Between 1897 and 1906 a number of these schools were upgraded to technical school with much greater subsidies. As the time went on, schools gradually changed their focus of technical training from the basic level to the middle level. The students of these schools came from middle- to upper-class rural

families, and after graduation, they ran their own business or became employees of local enterprises and related institutions (Satō 1987:31–45; Takeuchi 1987: 116–19, 123–6). They were the people who benefited from and responded to the government initiatives for the modernization of traditional industry.

IV

Economic historians have discussed capital, labour and land as main factors contributing to the Meiji industrialization, while business historians have focused on the strategy and structure of big business. The role of the state has been emphasized in the context of coping with external pressures and helping industries through various measures: protection, subsidies, the provision of capital and demand, and ideological injection of nationalism were among them. In none of these studies has the role of information and information-gathering been identified as a main factor, although it is often referred to in the actual narrative. A large body of non-economic literature relevant to the subject has not been properly incorporated into the explanation for industrialization either.

This is largely the fault of economics which assumes that information is free or can be dealt with as part of the transaction costs which are borne by the individual firm. The questions of who organized the information network, who shared the costs, and how effective it was must be addressed, especially with regard to its relevance to development policy. For an entrepreneur to think that he does not need an informational infrastructure is just as absurd as for him to think that he does not need roads and traffic wardens to carry out his business in central London. 'Market failure' occurs as frequently in the sphere of informational infrastructure as in the physical one. For example, the lack of training culture in Britain, typified by the large British firm's unwillingness to release their employees to learn Japanese before they are assigned to Tokyo, can be substantially improved if the government spends a small amount of money to subsidize language courses specially designed for business people. The cost for this would be minimal, compared to the budget needed to rescue the deficiency of London transport for example. Yet its effects are similar in that so many business plans and innovations can be contemplated once such an infrastructure is in place.

What I have illustrated in this chapter may have sounded to some as if I were talking about the workings of 'Japan Inc.' My main purpose here was to understand the workings of Japanese industrial

development from a specific angle, but I do hope to have done so without appealing to the 'unique' characteristics of Japanese society and culture. The society did need a strong ideological as well as economic motivation to create a sophisticated informational infrastructure and sustain the level of these activities. It was easy for the Meiji government to meet this requirement. It took the nineteenth-century British ideals of free trade and the freedom of enterprise seriously, and interpreted Continental institutional innovations on market research and technological aid to effect them. During the nineteenth century Britain collected overseas commercial information worldwide (Platt 1971), but she was reluctant to see the need for further state intervention, and decided not to take up new ideas such as the establishment of commercial museums. The monthly journal commonly known as *The Board of Trade Journal* (started in July 1886) was not as sensitive to the need to deliver information quickly as the Japanese counterparts throughout the nineteenth century, while its coverage was far more comprehensive. The commercial attaché system (started in 1880) and the commercial agent system (1899–1907) were introduced by the Foreign Office, while the Commercial Intelligence Branch at the Board of Trade started its services in 1899, all on a rather small scale. There was no regular information network which would connect overseas information directly with local business people (S. Tsunoyama 1986: 224–35). Japan, by contrast, followed the European lead, and went further to systematically connect overseas information with detailed local needs. To her, government intervention in information flows was an essential condition for free trade. It was a natural response to a set of historical circumstances in which bridging the linguistic and cultural gap particularly mattered. But the creation of an informational infrastructure is something which has a universal relevance to economic development.

Any market economy needs a system of feeding and storing business information through exhibits, demonstrations, on-the-job training and written information. In the Japanese case, an extensive use of written information and its public nature has been noted (Saxonhouse 1974: 159–63). A high literacy rate and a general appreciation of the value of commercial and technical knowledge made it possible to formalize information in accessible form and make it publicly available. The comparison with how other non-European countries responded to a similar situation raises an important question. Most of these countries did not have an opportunity to fully implement industrial policy, as they were either colonized or under

heavy western influence. In most of Asia and parts of Africa and Latin America, Chinese and Indian merchants and money-lenders acted as intermediaries between western and indigenous economies, taking advantage of the information gap and living on it. Indeed one of the main motivations behind the formation of local trade associations in Japan in the 1880s was to counter a strong organizational ability of Chinese merchant guilds and enhance the Japanese bargaining position against them (Kagotani 1990: 11–15). Local and regional suppliers of credit also played an important role in the interpretation of Eurocentric patterns of economic behaviour to suit local needs (Austin and Sugihara 1993: 19–21). But their knowledge was not publicly shared, particularly with indigenous peoples. Japanese institutions, by contrast, were normally non-profit-making bodies which disseminated information as if it were a public good. The public ownership of information was widely accepted and was hardly challenged as an act of depriving the intermediaries of their market opportunities. The use of public information was also clearly differentiated from the trickery which related to the wrong or unfair use of information.[9] The state thus found an important and legitimate role in economic development here. An urgent task is to understand how much these colonized nations had lost as a result of the lack of an informational infrastructure, and how much they had inherited such a colonial practice after independence.

NOTES

1 The idea of this chapter was first conceived when I participated in a joint research project on Japanese consular reports carried out at the Institute of Humanistic Studies, Kyoto University, in the period from 1982 to 1985. Much new material was collected and the idea of writing an economic history of information was gradually formed among the active members of the group headed by Professor Tsunoyama Sakae. I am grateful for the support and the stimulus with which they provided me. I also benefited from the comments of Professors T. C. Barker and Abe Takeshi. The usual disclaimer applies. In this chapter Japanese names appear in Japanese order, i.e. family name followed by first name.

2 Building up the military capacity remained a political priority, and the ratio of military expenditure to NNP remained high throughout the pre-war period. However, it would be wrong to conclude from this that the Japanese fiscal policy before 1936 was centred around these political needs (Nakamura 1985: 78–194).

3 Strictly speaking, there was an earlier, rather less centrally controlled wave of industrial promotion in the late 1870s (O. Saitō 1983: 265–94).

4 Johnson states that 'since the Matsukata reforms, and particularly after

the creation of the diet and the end of the 1894–95 war with China, the government's overall policy toward industry and foreign trade had become a more or less orthodox version of laissez faire', and concludes that 'industrial administration was almost nonexistent' (Johnson 1982: 88). This traditional (and now outdated) view has been formed, largely on the basis of the studies of the relationship between central government and big business. In fact MACA and the Ministry of Commerce and Industry (reorganized from MACA's non-agricultural wing in 1925) continued to be deeply involved in the protection and promotion of local merchants and manufacturers throughout the pre-Second World War period. In the post-war period the Ministry of International Trade and Industry (established in 1949) became more involved with the collaboration with large enterprises, while other agencies dealt with small- and medium-scale businesses.

5 By the early twentieth century many large enterprises formed a multi-unit structure in which hierarchical decision-making was a dominant feature. However, unlike Britain, Germany and the United States, many managers who were on a career path were employed at the factory- or office-level in Japan, and the top management were dependent on these educated salaried managers for the acquisition of modern technology. These points have been discussed by Chandler (1986: 68). Thus the bulk of general information was embodied and stored among the middle management, and general information flows occurred horizontally as well as through the top management. The presence of this horizontal flow assumes that general information can usefully be shared in a fully competitive environment, the notion which this chapter discusses in a public context. Some see such information-sharing practices (in-house and inter-firm) as a risk-sharing device. Aoki (1989: 7–48) has produced a theoretical discussion of the information structure of the Japanese firm.

6 *Business History* 23,3 (1981) contains papers on consular reports in ten western countries.

7 This initiative was separate from the earlier, rather less successful attempts to set up agricultural experimental stations in the 1870s (Y. Saitō 1968: 97–102).

8 Imai (1988: 205–29) discusses some aspects of economic justification for government intervention in research and development.

9 Thus, while the western concept of the private ownership of information was thought to be 'mean' by some Japanese, the Japanese understanding that any public information could be freely copied without permission often upset those westerners who came to Japan.

BIBLIOGRAPHY

Abe, Takeshi (1990) 'Menkōgyō (The cotton industry)', in Shunsaku Nishikawa and Takeshi Abe (eds), *Nihon Keizaishi 4: Sangyō-ka no Jidai (1)*, Tokyo: Iwanami Shoten.

Aoki, Masahiko (1989) *Information, Incentives, and Bargaining in the Japanese Economy*, Cambridge: Cambridge University Press.

Austin, G. and Sugihara, Kaoru (1993) 'Local suppliers of credit in the Third

World, 1750–1960: introduction', in G. Austin and K. Sugihara (eds), *Local Suppliers of Credit in the Third World, 1750–1960*, London: Macmillan.

Chandler, A. D. (1986) 'Managers, families, and financiers: response to comments by Hashimoto Jurō', in Kesaji Kobayashi and Hidemasa Morikawa (eds), *Development of Managerial Enterprise*, Proceedings of the Fuji Conference, vol. 12, Tokyo: University of Tokyo Press.

Fujita, Teiichirō (1988) 'Local trade associations (Dōgyō Kumiai) in prewar Japan', in Hiroaki Yamazaki and Matao Miyamoto (eds), *Trade Associations in Business History*, Proceedings of the Fuji Conference, vol. 14, Tokyo: University of Tokyo Press.

Gerschenkron, A. (1962) *Economic Backwardness in Historical Perspective*, Cambridge, MA: Harvard University Press.

Hatsumei Kyōkai (1974) *Tokkyo Seido 70-nenshi* ('Seventy Years of the Patent System'), Tokyo.

Imai, Kenichi (1988) 'Industrial policy and technological innovation', in Ryūtarō Komiya, Masahiro Okuno and Kōtarō Suzumura (eds) *The Industrial Policy of Japan*, London: Academic Press.

Inukai, Ichirō and Tussing, A. R. (1967) 'Kōgyō Iken: Japan's ten year plan', *Economic Development and Cultural Change* 16, 1: 51–71.

Johnson, C. (1982) *MITI and the Japanese Miracle: The Growth of Industrial Policy, 1925–1975*, Stanford: Stanford University Press.

Kagotani, Naoto (1990) '1880 nendai no Ajia karano "Shōgeki" to Nihon no Hannō: Chūgokujin Bōekishō no Ugoki ni Chūmokushite' ('The Asian "Impact" in the 1880s and the Japanese response: with special reference to the activities of Chinese merchants'), *Rekishigaku kenkyū* 608: 1–18, 62.

Makino, Terutomo (1911) *Gendai Hatsumeika-den* ('Biographies of the Contemporary Inventors'), Tokyo: Teikoku Hatsumei Kyōkai.

Miyamoto, Matao (1988) 'The development of business associations in prewar Japan', in Hiroaki Yamazaki and Matao Miyamoto (eds), *Trade Associations in Business History*. Proceedings of the Fuji Conference, vol. 14, Tokyo: University of Tokyo Press.

Nakamura, Takafusa (1983) *Economic Growth of Prewar Japan*, New Haven: Yale University Press.

—— (1985) *Meiji, Taishō-ki no Keizai* ('The Japanese Economy in the Meiji and Taishō Periods'), Tokyo: Tokyo Daigaku Shuppankai.

Nakaoka, Tetsurō, Ishii, Tadashi and Uchida, Hoshimi (1986) *Kindai Nihon no Gijutsu to Gijutsu Seisaku* ('Technology and Technology Policy of Modern Japan'), Tokyo: Tokyo Daigaku Shuppankai.

Nōshōmushō Shōkōkyoku (1913) *Kaigai Jitsugyō Renshūsei Ichiran* ('A List of Overseas Business Trainees'), Tokyo.

Platt, D. C. M. (1971) *The Cinderella Service: British Consuls Since 1825*, London: Longman.

Rosovsky, H. (1966) 'Japan's transition to modern economic growth, 1868–1885', in Henry Rosovsky (ed.), *Industrialization in Two Systems: Essays in Honor of Alexander Gerschenkron*, New York: John Wiley and Sons.

Saitō, Osamu (1983), 'Chihō Reberu no Shokusan Kōgyō Seisaku' ('The industry and enterprise promotion policy at the local level'), in Mataji Umemura and Takafusa Nakamura (eds), *Matsukata Zaisei to Shokusan Kōgyō Seisaku*, Tokyo: Tokyo Daigaku Shuppankai.

—— (1984) 'Meiji Kōki no Fuken Kangyō Seisaku' ('Prefectures' policies

for enterprise promotion in the latter half of the Meiji period'), *Keizai Kenkyū* 35, 3: 236–48.

Saitō, Yukio (1968) *Nihon Nōgakushi* ('A History of Agricultural Studies in Japan'), Tokyo: Taisei Shuppansha.

Satō, Mamoru (1987) 'Vocational education in the takeoff period', in Toshio Toyoda (ed.), *Vocational Education in the Industrialization of Japan*, Tokyo: The United Nations University.

Saxonhouse, G. (1974) 'A tale of Japanese technological diffusion in the Meiji period', *Journal of Economic History* 34, 1: 149–65.

Sugihara, Kaoru (1980) 'Patterns of intra-Asian trade, 1898–1913', *Osaka City University Economic Review* 16: 55–76.

—— (1982) 'Shōhin Chinretsusho to "Shōhin Chinretsusho Hōkoku" ni tsuite' ('On the Commercial Museum and the "Reports of Commercial Museum"'), mimeo, read at the Consular Reports Project Seminar, 7 May 1982.

—— (1984) 'Daiichiji Taisenmae no Indo-Shijō ni okeru Nihonsei Menmeriyasu Seihin no Shintō' ('The penetration of Japanese cotton underwear into the Indian market before World War I'), *Keizaiguku Zasshi* 84, 4 & 5: 70–87.

—— (1990) 'Shōgyō Zasshi' ('Commercial Journals') in Shirō Sugihara (ed.), *Nihon Keizai Zasshi no Genryū*, Tokyo: Yūhikaku.

Sugimoto, Toshihiro (1986) 'Meiji Zenki no Nihon Matchi Yushutsu to "Ryōji Hōkoku"' ('The exports of Japanese matches in the early Meiji period and the "Consular Reports"'), in Sakae Tsunoyama (ed.), *Nihon Ryōji Hōkoku no Kenkyū*, Tokyo: Dōbunkan.

Takashima, Masaaki (1986a) 'Ryōji Hōkoku Seido no Hatten to "Ryōji Hōkoku" no Kankō' ('The development of the Consular Reports System and the publication of the "Consular Reports"'), in Sakae Tsunoyama (ed.), *Nihon Ryōji Hōkoku no Kenkyū*, Tokyo: Dobunkan.

—— (1986b) 'Shōhin Chinretsusho ni tsuite' ('On the Commercial Museum'), in Sakae Tsunoyama (ed.), *Nihon Ryōji Hōkoku no Kenkyū*, Tokyo: Dōbunkan.

Takeuchi, Johzen (1987) 'Machinery: the Hiroshima prefectural worker training school, dyeing and weaving: the Minami-Tsuru Dyeing and Weaving School', in Toshio Toyada (ed.) *Vocational Education in the Industrialization of Japan*, Tokyo: The United Nations University.

—— (1991) *The Role of Labour-Intensive Sectors in Japanese Industrialization*, Tokyo: United Nations University Press.

Tsunoyama, Sakae (1981) 'Japanese consular reports', *Business History* 23, 3: 284–7.

—— (1986) 'Igirisu no Ryōji Seido oyobi Ryōji Hōkoku' ('The British consular system and consular reports'), in Sakae Tsunoyama (ed.) *Nihon Ryōji Hōkoku no Kenkyū*, Tokyo: Dōbunkan.

Tsunoyama, Yukihiro (1986) 'Nōshōmushō no Kaigai Bōeki Jōhō' ('Overseas trade information collected by the Ministry of Agricultural and Commercial Affairs'), in Sakae Tsunoyama (ed.), *Nihon Ryōji Hōkoku no Kenkyū*, Tokyo: Dōbunkan.

Yokomae, Shōsuke (ed.) (1911) *Meiji Shōkō-shi* ('A history of commerce and industry in the Meiji period'), Tokyo: Shōbundō.

Yui, Tsunehiko (1964) *Chūshō Kigyō Seisaku no Shiteki Kenkyū* ('A Historical Study of the Policy for Promoting Small and Medium Sized Firms'), Tokyo: Tōyō Keizai Shinpōsha.

98 – 110

5 American historians and the concept of the communications revolution

Richard R. John

~~84~~ 86
L96 U5 ~~L96~~ L D83

I

For more than 50 years, it has been conventional for historians to posit that the United States experienced a 'communications revolution' at some point between the eighteenth century and the present day. Though the concept is not, as its originator conceded, 'particularly euphonious' (Albion 1932: 720), it has played a prominent role in a variety of notable studies of American life (Bledstein 1976; Chandler 1977; Formisano 1983; Susman 1984; Brown 1989; Gilmore 1989). Indeed, it would be hardly an exaggeration to suggest that the concept has played for historians of communications a role analogous to that which the notion of the frontier has played for historians of the American West.

Like 'industrialism', 'mercantilism', and the other general concepts that historians invoke to explain the large-scale processes that have figured so prominently in the making of the modern world, the idea of the communications revolution has eluded precise definition. Most would probably agree with the British literary critic Raymond Williams that it has been a 'long' revolution in the sense that it occurred over a relatively extended period of time (Williams 1961). Few would deny that it has come to exert a profound influence not only upon politics and the economy, but also upon the very way we think about the past. Yet there is no consensus as to precisely which sequence of events it is meant to explain or even, for that matter, when it began. Until recently, there was even some disagreement as to how it ought to be spelled.[1]

This chapter seeks to clarify what historians of the United States have meant when they have written about the communications revolution. No attempt has been made to be comprehensive. Rather, it is my intention to sketch a few of the more influential ways in which

this concept has been deployed and to suggest how insights drawn from historical sociology and literary theory might help us to improve our understanding of the phenomenon that it seeks to explain.

II

The first historian to write extensively about the idea of the communications revolution was Robert Albion, a maritime historian who is best remembered today as the author of the *Rise of New York Port, 1815–1860* (Albion 1939). According to Albion, the concept described a constellation of changes that had taken place in Great Britain and the United States in the period between 1760 and the present day (Albion 1932, 1933). Albion chose 1760 as his starting point because of his conviction that it marked a decisive turning point in the *speed* with which information, people and goods moved through the economy. Prior to 1760, Albion explained, the maximum speed rarely exceeded 20 miles per hour, which was, as he put it, 'not impressive' (Albion 1933: 14). For Queen Elizabeth no less than for Emperor Augustus, the fastest means of communication was a mounted horse express.

In the late eighteenth century, all this would change. In 1760 and each following decade a 'greater development' occurred in the speed with which people, information and goods could move through the economy than had taken place during the preceding 1,500 years (Albion 1933: 13). To make his point, Albion listed a dozen technological innovations that had, in one way or another, increased the speed of movement over space (Albion 1933: 16). Year after year and space-destroying innovation after space-destroying innovation, one improvement succeeded another in a seemingly inexorable upward spiral of people, places and dates. At the top of Albion's list was the completion of the Bridgewater Canal in 1761 and the beginning of 'scientific' road construction in 1803. Next followed the steamboat, the railroad, the electric telegraph, the transatlantic cable, the telephone, the interurban, the automobile, wireless transmission, the airplane and the radio.

Albion's preoccupation with speed led him to highlight the importance of the communications revolution in the United States. In Great Britain, Albion observed, it should come as no surprise that the communications revolution was closely linked with, and largely dependent upon, a prior revolution in industry. After all, given the small size of the country, there was simply not that much space to destroy. In the United States, in contrast, the enormous size of the

country meant that the industrial revolution could not take place until a communications revolution had already occurred. Here, Albion observed, improvements in communications technology had 'performed wonders' while the enterprises that would spark the industrial revolution remained nothing more than 'infants' (Albion 1932: 719).

Albion's preoccupation with communications technology might lead one to suppose that he would place special stress upon the constructive role of public policy. After all, most of the communications technologies that Albion listed had either received massive amounts of public support or, in the case of the postal system, were under direct government control. Curiously, however, Albion said surprisingly little about who funded these innovations – or, for that matter, precisely why they came into being when they did. At no point, for example, did he draw any special attention to the fact that, at least in the United States, the rapid expansion of the postal system and the boom in internal improvements coincided almost exactly with the establishment of an effective central government following the adoption of the federal constitution in 1788.

Even more troubling was Albion's almost obsessive preoccupation with speed. While it might seem plausible to lump together all communications innovations as space-destroying, this notion cannot withstand close scrutiny. For one thing, it is open to the charge of anachronism. In 1760, at the start of Albion's communications revolution, no contemporary observer would have perceived communications as slow. After all, there had never been a time when it had been faster (Steele 1978, 1986). In addition, it greatly oversimplifies a complex process by assuming that a wide variety of innovations can be grouped together under a single rubric. Roads and canals were important for many reasons that had little to do with the speed with which they moved information, people and goods, from place to place. After all, the coal barges that passed through the Bridgewater Canal were pulled by horse, a means of transportation that was hardly new in 1760. Far more important was the role of the canal in increasing the capacity of this movement and its penetration into the hinterland. Similarly, the postal system facilitated not only the rapid movement of information over space, but also the regular and reliable transmission of information touching on commerce and public affairs (Mueller 1986; John 1989).

A further problem with Albion's approach can be traced to his extraordinarily wide-ranging discussion of the effects that this communications revolution supposedly wrought. In analysing the innovations themselves, Albion focused quite narrowly on their role in

increasing the speed of movement over space. In commenting on their effects, however, he was decidedly less restrained. New York City, Albion proclaimed was 'essentially' a 'product' of the communications revolution. By the early nineteenth century, Albion added, the United States had entered a veritable 'age of speed' (Albion 1933: 21). It was almost as if, in describing these effects, Albion found himself overwhelmed by a kind of millennial zeal.

Albion may have been the first historian to describe the role of communications technology in such expansive terms. Yet he was by no means the first to rhapsodize about their effects. From the postal system and the electric telegraph to the telephone and the computer, every major innovation in the transmission and processing of information has been hailed by contemporary observers as a harbinger of a new order of the ages (Czitrom 1982; John 1988, 1990). In 1832, moral philosopher Francis Lieber praised the postal system as 'one of the most effective instruments of civilization' whose effects were comparable to those of the printing press and the mariner's compass (Lieber 1832: 289). Five years later, travel writer Francis Grund hailed the postal system and the press for having 'revolutionized' the world (Grund 1837: 120, 389). Lieber and Grund, it might be noted, wrote long before the commercialization of the electric telegraph in 1844, the event that is often hailed as the starting point for the contemporary preoccupation with communications technology as an agent of change (Czitrom 1982).

In one respect, Albion's treatment of these effects was understandable. As cultural historian Dolores Greenberg has observed, economic historians often rely upon the language of contemporary discourse to make sense of the large-scale processes that they describe (Greenberg 1990). Albion was well aware of this and, at one point even went so far as to quote approvingly an effusive paean to communications technology that had been penned by writer Jack London (Albion 1933: 24). Indeed, Albion may well have obtained the germ of his concept from the flamboyant rhetoric that he would have encountered in the course of his research for his book on the port of New York. In another sense, however, it is curious that Albion proved so unwilling to break with convention. After all, to a far greater extent than most historians of his day, he was sensitive to the importance of infrastructural innovations whose effects had little to do with speed. Given this circumstance, Albion's reluctance to dissent from orthodoxy provides yet another example of the remarkable extent to which historians are constrained by the narrative strategies upon which they rely in making sense of the past.

III

While Albion himself did little to answer the myriad questions that his essays had posed, later historians would transform the concept of the communications revolution into a valuable analytical tool. Among those historians to grapple with Albion's concept, perhaps the most imaginative was Alfred D. Chandler, Jr. That Chandler should find merit in Albion's ideas was hardly surprising. During the 1940s, when he was a graduate student at Harvard, Chandler served as Albion's teaching assistant and learned at first hand about his expansive ideas regarding the role of communications in the shaping of the American past.[2]

In certain respects, Chandler's formulation of the concept was similar to Albion's. Like Albion, he emphasized movement over space and, in particular, what he termed 'economies of speed'. Chandler also followed Albion by placing great stress on technological innovations such as the steam railroad and the electric telegraph. He even retained Albion's spelling: in contrast to most recent historians, he continued to spell 'communication' as a singular noun, that is, without the 's'.

Chandler also shared Albion's sensitivity to the importance of infrastructural innovations in communications technology. Indeed, Chandler was among the first historians to introduce the concept of a communications infrastructure to the historians' lexicon (Chandler 1977). None the less, at various points Chandler came close to treating these innovations as nothing more than the product of prior changes in transportation or industry. For example, in his discussion of the postal system, Chandler treated the establishment of a network of specially designated distribution centres as the product of changes set in motion by the coming of the steam railroad even though, in point of fact, these centres had been in existence for over 50 years (Habersham 1800: 38). Similarly, Chandler treated the express industry as little more than an ancillary arm of the steam railroad, even though the former operated independently of the latter from the 1830s until the First World War.

On the critical issue of periodization, however, Chandler broke new ground. For Albion, the communications revolution was a product of the eighteenth century, and, in particular, of the radical transformation in the movement of information, people and goods that began with the completion of the Bridgewater Canal. For Chandler, however, the revolution had to wait until the nineteenth century and a sequence of events that included the commercialization

of the electric telegraph in 1844. The critical constraint, according to Albion, was the slow speed with which information, people and goods moved through the economy before 1760. For Chandler, it was the absence of new sources of energy before 1840 and, in particular, the absence of electricity and the inaccessibility of a cheap supply of coal (Chandler 1977: 76, 192).

Chandler was not the first historian to tinker with Albion's periodization in this way. As early as 1951, Lee Benson had proposed that the concept of the communications revolution be confined to the period after 1850, a suggestion that a number of historians have since seen fit to adopt (Benson 1951; Schonberger 1971; Bledstein 1976; Susman 1984; Schlereth 1992).[3] None the less, in at least two respects, Chandler's formulation marked a distinct conceptual advance. First, while Chandler was by no means insensitive to the importance of the postal system and internal improvements, he gave greater prominence to innovations that were dependent upon new forms of energy like the steam railroad and electric telegraph. Second, Chandler broke the link that Albion had made between communications and transportation. In the spirit of a venerable eighteenth-century tradition, Albion had presumed communications to embrace the movement not only of information but also of people and goods. Following what was rapidly becoming a twentieth-century convention, Chandler confined it to the movement of information, and, above all, to information relevant to commerce and industry. To explain the parallel transformation in the movement of people and goods, he borrowed the concept of the 'transportation revolution' from George Rogers Taylor, who had included it in the title of a survey of the early nineteenth-century American economy that he had published in 1951 (Taylor 1951).

Far different in his approach was Thomas Cochran. Like Chandler, Cochran was a business historian who had done a good deal of original research on the nineteenth century. Unlike Chandler, however, Cochran retained Albion's traditional preoccupation with the period before 1840. In a notable essay on the 'business revolution' that Cochran published in 1974, as well as in a later book, Cochran devoted special attention to the changes in the American economy that occurred in the period between 1790 and 1840 (Cochran 1974, 1981). Despite the fact that Cochran refrained from using the concept of a communications revolution in either his essay or his book, there can be little question but that the changes that he described had much in common with those that Albion had focused on over 40 years before. Though Cochran cast only a perfunctory glance at Albion's

corpus in his notes, he acknowledged a major debt to Allan Pred, a historical geographer whose own study of interurban information flows in the period between 1790 and 1840 had been heavily influenced by Albion's *Rise of New York Port* (Cochran 1974: 1451, 1464; Pred 1973).

Cochran's business revolution echoed Albion's communications revolution in a number of respects. Like Albion, Cochran highlighted the period prior to the coming of the railroad and telegraph. And like Albion, Cochran accorded enormous significance to speed – or, as Cochran put it, the 'increase in the tempo of business activity' that made it possible for entrepreneurs to make decisions based on 'better information', including 'more up-to-date knowledge of the state of the market' (Cochran 1974: 1463–4).

Notwithstanding these similarities, Cochran flatly rejected Albion's focus upon technological innovation. For Cochran, this focus upon technology overlooked the role of more fundamental changes originating in 'social structural conditions' such as the 'demands' placed on technology by 'new elements' in the 'business–political–social system' (Cochran 1974: 1449). Above all, Cochran rejected Chandler's focus upon technological innovations based on new forms of energy such as electricity and coal. The 'most important' factor in American economic development, Cochran proclaimed, had *nothing* to do with industry or, for that matter, with 'machinery using nonmanual power' (Cochran 1974: 1463, 1449). Rather, it was a social structure that facilitated the rapid processing of business information and a cultural environment conducive to entrepreneurship.

Chandler and Cochran exemplify two of the principal ways in which American historians have drawn upon Albion's seminal insight into the role of the communications revolution as an agent of change. Historians sympathetic to Chandler's preoccupation with the role of technological innovation in the historical process tend to treat the communications revolution as a product of the changes set in motion by the steam railroad and the electric telegraph. This is true even of those historians who, like Warren Susman, are far more interested in popular culture than in the dynamics of technological change (Susman 1984). On the other hand, historians interested primarily in culture or social structure tend, like Cochran, to focus on the period prior to 1840. This is also the case for those who, like Ronald Formisano, remain highly sensitive to the role of institutional innovation as an agent of change (Formisano 1983).

IV

Although Chandler and Cochran are often understood to exemplify antithetical approaches to the study of economic development, their treatment of communications shares a number of common features. Both identify communications primarily with the movement of information over space and both presume changes in communications technology to follow changes originating in some other realm.

Far different in this regard is the historical sociologist Daniel Bell. Though Bell's interests are confined almost exclusively to the twentieth century, his insights into the communications revolution during this period have much to offer historians of the less recent past (Bell 1979). Central to Bell's approach is the concept of a 'communications infrastructure'. By this, Bell means something more than a discrete technological innovation such as the electric telegraph or even a single technological attribute such as speed. Rather, he means a complex configuration of interrelated components that follows its own internal logic and that facilitates the processing of information as well as its movement over space. It is, in short, less a product of changes occurring elsewhere in the economy than an autonomous agent of change. To illustrate what he means, Bell highlights the myriad implications of the gradual merger of telecommunications and teleprocessing that has come to be known as compunications.

Bell is surprisingly vague about precisely how and why this infrastructure came into existence when it did. One thing is certain: though Bell concedes that public-policy considerations may come to loom large in the future, he is convinced that they played at best an incidental role in the past (Beniger 1986: 184–6). As an alternative, Bell points to the impetus that this infrastructure received from a fundamental transformation in the character of work. In the nineteenth century, Bell posits, work continued to be measured in terms of the physical labour it demanded. In the twentieth century, however, work has come to be based upon the knowledge it embodied. The communications infrastructure, Bell explains, is a product of this epochal social change (Bell 1979).

Few historians are likely to share Bell's dismissive attitude toward the communications infrastructure in the less recent past. None the less, his description of the communications infrastructure as a configuration of interrelated components complements the more narrowly focused accounts of Chandler and Cochran. In this way, by drawing our attention to the autonomous role of the

communications infrastructure in the present, Bell points us towards a fuller understanding of its importance in the past.

V

If Bell highlights the importance of the communications infrastructure as an agent of change, James Carey highlights the decisive role of public policy in setting this infrastructure in motion (Carey 1989). At first glance, nothing would seem to be further from Carey's intentions. A communications critic interested primarily in the explication of texts, Carey is hardly the sort of scholar one would assume to have valuable suggestions for historians interested in the dynamics of institutional change.

None the less, it is here that Carey makes what is perhaps his most notable contribution. Like Albion, Carey is much impressed by the distinctive space-binding character of long-distance communications in the United States. Yet while Albion takes this circumstance more or less for granted, Carey treats it as a problem to be explained. Carey's interpretation hinges on the highly suggestive contrast he draws between a communications policy intended to facilitate the transmission of information over space, and a policy intended to serve as a container for shared community values. Like the great Canadian economic historian, Harold Innis (Innis 1951), to whom Carey acknowledges a major debt, Carey is convinced that the communications infrastructure in the United States has systematically subordinated the promotion of community values to the conquest of space. Indeed, so pronounced is this shift that Carey goes so far as to hint that, were he to 'flirt' with 'more deterministic language', he might well want to describe the United States as the 'product' of a communications policy that had consistently promoted 'literacy, cheap paper, rapid and inexpensive transportation, and the mechanical reproduction of words' (Carey 1989: 2).

In explaining this outcome, Carey looks neither to culture and social structure nor even to technology. Instead, he turns to what might best be described as political fiat. In particular, Carey raises the distinct possibility that the American communications infrastructure was the product less of unintended consequences than of deliberate design. Though Carey is vague about who brought this outcome about, his scattered references to the intentions of the Founding Fathers suggest that he would direct our attention to the decade immediately following the adoption of the federal constitution in 1788. This is a most valuable lead. After all, it was during the

1790s, more than half a century prior to the coming of the steam railroad and the electric telegraph, that Congress made its pivotal public-policy decisions regarding the postal system and the press, the two most important elements of the post-constitutional communications infrastructure. And it was in this decade, rather than in the 1760s or the 1850s, that the modern American communications infrastructure was born (Pool 1983; John 1993).

Carey's analysis is not without its problems. At times, his account of the alternative, community-based communications policy verges on the sentimental. It is worth remembering that the staunchest nineteenth-century advocates of the policy for which Carey expresses such evident admiration included southern slaveholders wary of the influence of ideas that might prove subversive to their enormous investment in slaves. In addition, Carey completely overlooks the pivotal role of the postal system, the principal post-constitutional long-distance communications technology. Indeed, when Carey postulates that the commercialization of the electric telegraph marked a 'decisive and cumulative break' in American history by serving as the 'critical instrument' in expanding the price system into the hinterland, one is tempted to observe that Carey himself has fallen victim to the very rhetoric of the electrical sublime that he himself has so persuasively debunked (Carey 1989: 214, 222).[4] Long before the advent of commercial telegraphy, the postal system had created a national market. And for many decades after the commercialization of the telegraph, the postal system remained a far more important link to the wider world for the vast majority of the inhabitants of the United States (John 1993).

VI

Notwithstanding these shortcomings, Carey does highlight, to a far greater extent than Chandler or Cochran, the crucial role of human agency in the making of the communications infrastructure in the United States. Indeed, it would not be too much of an exaggeration to suggest that it was precisely the space-binding communications policy that Carey has so perceptively described that best explains the space-destroying communications revolution that Albion so enthusiastically sketched. Carey himself would presumably be wary of making such a linkage, sceptical as he is of the merits of ideas such as the communications revolution (Carey 1989: 2). Yet there is good reason to hope that historians, preoccupied as they are with a somewhat different set of concerns, may well choose to follow his

lead. Like so many of the catch phrases that historians invoke to make sense of the past, the concept of the communications revolution was devised to explain a phenomenon that unquestionably occurred. By returning the concept to the period for which it was initially devised and by reorienting our sights to embrace not only technology, culture and the social structure but also the communications infrastructure and public policy, it may well become possible to improve our understanding of this important, yet little understood, transformation in the making of the modern world.

NOTES

1 Prior to the Second World War, it was customary to spell 'communication' without the final 's'. Since that time, however, most historians have added a final 's', and for the sake of consistency I have followed this convention throughout.
2 Alfred D. Chandler, Jr, to Richard R. John, 19 June 1992.
3 Benson, however, later changed his mind and decided to locate the beginnings of the communications revolution in the years immediately after the Treaty of Ghent in 1815 (Benson 1961: 13).
4 Illustrative of Carey's neglect of the postal system is his claim that the receipt of a letter through the postal system is an 'old habit' while the receipt of a newspaper is 'modern' (Carey 1989: 1). In reality, the opposite is closer to the truth. Following the enactment of the Post Office Act of 1792, with its generous subsidies for the newspaper press, thousands of Americans grew accustomed to receiving a newspaper through the postal system who seldom, if ever, received a letter that had been sent through the mail.

BIBLIOGRAPHY

Albion, R. G. (1932) 'The communication revolution', *American Historical Review* 37, 4: 718–20.
—— (1933) 'The communication revolution 1760–1933', *Newcomen Society Transactions* 14: 13–25.
—— (1939) *The Rise of New York Port, 1815–1860*, New York: Scribner's Sons, 1939.
Bell, D. (1979) 'The social framework of the information society', in M. L. Dertouzos and J. Moses (eds), *The Computer Age: A Twenty-Year View*, Cambridge, MA: MIT Press.
Beniger, J. R. (1986) *The Control Revolution: Technological and Economic Origins of the Information Society*, Cambridge, MA: Harvard University Press.
Benson, L. (1951) 'The historical background of Turner's frontier essay', *Agricultural History* 25, 2: 59–82.
—— (1961) *The Concept of Jacksonian Democracy: New York as a Test Case,* Princeton: Princeton University Press.

Bledstein, B. J. (1976) *The Culture of Professionalism: The Middle Class and the Development of Higher Education in America*, New York: W. W. Norton & Company.

Brown, R. D. (1989) *Knowledge is Power: The Diffusion of Information in Early America, 1700–1865*, Oxford: Oxford University Press.

Carey, J. W. (1989) *Communication as Culture: Essays on Media and Society*, London: Unwin Hyman Ltd.

Chandler, A. D., Jr (1977) *The Visible Hand: The Managerial Revolution in American Business*, Cambridge, MA: Harvard University Press.

Cochran, T. C. (1974) 'The business revolution', *American Historical Review* 79, 5: 1449–66.

—— (1981) *Frontiers of Change: Early Industrialism in America*, Oxford: Oxford University Press.

Czitrom, D. J. (1982) *Media and the American Mind from Morse to McLuhan*, Chapel Hill: University of North Carolina Press.

Formisano, R. P. (1983) *The Transformation of Political Culture, Massachusetts Parties, 1790s–1840s*, Oxford: Oxford University Press.

Gilmore, W. J. (1989) *Reading Becomes a Necessity of Life: Material and Cultural Life in Rural New England, 1780–1835*, Knoxville: University of Tennessee Press.

Greenberg, D. (1990) 'Energy, power, and perceptions of social change in the early nineteenth century', *American Historical Review* 95, 3: 693–714.

Grund, F. J. (1837) *The Americans in their Moral, Social, and Political Relations*, Boston: March, Capen, and Lyon.

Habersham, J. (1800) *The Post Office Law, with Instructions, Forms and Tables of Distances*, Washington: Charles Cist.

Innis, H. A. (1951) *The Bias of Communication*, Toronto: University of Toronto Press.

John, R. R. (1988) 'Out of control', *Isis*, 79, 4: 675–9.

—— (1989) 'Managing the mails: the postal system, public policy and American political culture', unpublished Ph.D. dissertation, Harvard University.

—— (1990) 'Remembering McLuhan', *Reviews in American History*, 18, 3: 419–24.

—— (1993) 'Communications and information processing', *Encyclopedia of Social History*, 3 vols, ed. Mary Kupiec Cayton, Elliot J. Gorn and Peter W. Williams, New York: Charles Scribner's Sons, vol. 3, pp. 2349–61.

Lieber, F. (1832) 'Posts', *Encyclopedia Americana*, 10: 289–98.

Mueller, M. (1986) 'The currency of the word: war, revolution, and the temporal coordination of literate media in England, 1608–1655', unpublished M.A. thesis, University of Pennsylvania.

Pool, I. S. (1983) *Technologies of Freedom*, Cambridge, MA: Harvard University Press.

Pred, A. R. (1973) *Urban Growth and the Circulation of Information: The United States System of Cities, 1790–1840*, Cambridge, MA: Harvard University Press.

Schlereth, T. A. (1992) *Victorian America: Transformations in Everyday Life,* New York: HarperCollins.

Schonberger, H. D. (1971) *Transportation to the Seaboard: The 'Communication Revolution' and American Foreign Policy, 1860–1900.* Westport, CT: Greenwood Press.

Steele, I. K. (1978) 'Moat theories and the English Atlantic, 1675 to 1740', *Historical Papers* (Canadian Historical Association): 18–33.
—— (1986) *English Atlantic, 1675–1740: An Exploration of Communication and Community*, Oxford: Oxford University Press.
Susman, W. I. (1984) *Culture as History: The Transformation of American Society in the Twentieth Century*, New York: Pantheon.
Taylor, G. R. (1951) *The Transportation Revolution, 1815–1860*, New York: Holt, Rinehart and Winston.
Williams, R. (1961) *The Long Revolution: An Analysis of the Democratic, Industrial and Cultural Changes Transforming our Society*, New York: Columbia University Press.

Part II

Business context

113-35

6 Product policies in two French computer firms

SEA and Bull (1948–64)[1]

L 86 / D 83

Pierre-E. Mounier-Kuhn

INTRODUCTION

The invention of the stored-program computer in the late 1940s is a classic example of the emerging 'new technologies' (Salomon 1986): that is, products born in basic research laboratories, which then went on to revolutionize industry. For the manufacturers of data-processing machines, the irruption of electronics and of the computer required new investments in knowledge acquisition. From the technical point of view, R&D departments in these firms had to learn to exchange information and ideas with the academic research community; this, due to the scientific origin of the stored-program computer, as well as to the growing R&D costs, which most companies could not afford alone. From the commercial point of view, the computer, which is essentially a universal data-processing machine, gradually merged together the business, scientific, industrial automation, and telecommunications markets. The manufacturers, hitherto ensconced in these particular niches, had to expand their knowledge to include these various fields, which became 'market segments'. Lastly, the high level of investment necessary to sustain the innovation race had to be recouped through a worldwide commercial expansion.

The genesis of computing in France is broadly known, thanks to the recent efforts of historians and computer pioneers (INPG 1988; Conservatoire National des Arts et Métiers 1990).[2] It is now possible to analyse the behaviours of the different players in this adventure. This is particularly true of the first two French companies to venture into electronic computing: SEA and Bull. During the 1950s, they embodied two opposite approaches to innovation:

The SEA progressed from scientific computing to business data processing; it worked in close contact with the scientific and

military milieux; from the start, it aimed at being one of the 'doers' at the heart of the computer revolution, and its managers seemed to have a fairly clear view of the direction taken by technical progress, according to their writings (SEA/1949). The SEA is comparable to some extent with companies like Elliott in Britain, ERA and Control Data in the United States.

The Compagnie des Machines Bull took the opposite course – from business punched-card machinery to electronics and to scientific computing; it knew the business clientele intimately, and considered SEA's markets marginal; it had a reactive attitude in the face of the computer revolution and of the innovations launched by competitors. Its position and its behaviour were rather similar, for instance, to ICL's (British Tabulating Machines, at the time) (Campbell-Kelly 1990).

This chapter, which is part of a general study on the history of computing in France, attempts to answer such questions as: how did SEA and Bull behave in the crucial decade when the stored-program computer, a revolutionary innovation, appeared? How did they perceive technical and market evolutions? How did these perceptions shape their product strategies? How did they go about obtaining the information necessary in formulating these strategies?

THE SEA

A long-term product policy

Created in 1948 by an electronics engineer, François-Henri Raymond, the Société d'Electronique et d'Automatisme was both a research group and a manufacturer specializing in electronic computing.[3] The SEA initially established its revenue and its reputation by designing analogue calculators, process-control devices and flight simulators – all systems based on relatively well-mastered techniques (linear electronics) at the time. SEA's main clients were the military, research centres and higher education, and the machine-tool industry.

However, the long-term objective of the SEA was to develop numerical data processing – what the French have called *informatique* since 1962. This project had been in the air since the very beginning of the SEA, whose first shareholders were attracted by the potential of digitally controlled machine-tools. An internal SEA report, dated 1949, describes the architecture of a stored-program computer, considers a cathode-tube storage, and gives an example of an

application program. During that same year, a team of engineers began designing and soldering digital circuits. In 1955 the SEA installed the first stored-program computers in France in an atmosphere of enthusiastic inventiveness: virtual memory, patents on word processing, teleprocessing with the CNET, project of electronic telephone switching system, etc. The SEA then introduced its CAB 500, a small computer with a programming language in French, 'PAF' (*Programmation automatique des formules*); more than 100 units were sold in France and abroad.

Specialized in scientific applications up until the late 1950s, SEA's next move was to launch computers for the business market. To SEA's directors, this was a logical progression for a machine envisioned as universal. Raymond had explained this at the first SICOB (the Paris office-equipment fair) conference, urging his audience, in his rather provocative manner, to switch from punched cards to magnetic storage as soon as possible. In May 1957, an SEA CAB 2024 computer with magnetic tapes was installed at Monsavon-L'Oréal for the processing of commercial statistics. In 1960 the SEA introduced its SEA 3900 transistorized business computer, nicknamed 'CABAN' (*CAlculateur BANcaire*) as it was designed in close cooperation with the Crédit Lyonnais.

The technical and commercial conception of this machine was remarkable. It incorporated the latest technologies of the time, compatible with its cost, and was exactly geared to the market needs: a medium-sized business computer, reliable and easy enough to be used by non-specialists. That same year, IBM put a comparable product on the market, the IBM 1401. This was the first computer in history of which more than 10,000 units were built, and its success surprised everyone, including IBM; this computer, which came equipped with punched-card peripherals and an excellent fast printer, literally rang the death knell of the traditional punched-card tabulators (Bashe *et al.* 1986). With its 3900, SEA was one of the few firms able to offer a serious and competitive alternative to the IBM 1401. None the less, the SEA 3900 was not a 'response' to the IBM 1401, as both manufacturers had simultaneously exploited the new possibilities of the technology.

Yet, the SEA sold no more than 40 units of the 3900. The reason was that SEA, though it enjoyed a good reputation in the scientific milieux, was unknown and had no image whatsoever in the business market. It did not have a sales and maintenance force comparable to the international commercial networks built up by IBM and Bull over several decades.[4] The SEA thus continued to rely mainly on its

machines for research and automation, and on its patent revenues, while developing new projects. Perhaps with time, SEA would have bridged this commercial gap, and taken over market shares from the old punched-card machine manufacturers, as DEC, Nixdorf and others did. The French firm was not given time enough to find out. In 1967 the SEA (800 employees) was merged with another firm to create the ill-fated Compagnie Internationale pour l'Informatique, in the context of the Plan Calcul.

Technology and knowledge transfers

In 1955, more than 100 stored-program computers already existed in the world, most of them in the United States and in Great Britain, where some had been in service since the end of the 1940s. The 'newly computerized' countries, like France, largely benefited from the technologies, from the experience and from the know-how accumulated in Great Britain and America. These were adopted and developed according to the implementing countries' particular talents, to their possibilities, to their limitations, and to their own experience. How were these technology and knowledge transfers carried out?

The different methods of technology transfer can be roughly divided into two categories (Aspray 1986: Campbell-Kelly 1982). The first corresponds to the way in which knowledge is passed on in the university milieu and has the following characteristics: knowledge is evaluated according to its contribution to scientific learning; it has to be spread as widely as possible, with no concern as to eventual profits; it deals with fundamental concepts rather than development processes; it is passed on through the usual communication channels of the scientific community (journal articles, reports, conferences . . .); the government is a main actor in this type of technology transfer.

The second mode of technology transfer is that which takes place in the industrial world. The technology is evaluated in terms of its contribution to the enterprise's survival and profits; its diffusion is subject to the rules governing industrial property and commercial transactions (the trading of patents, licences and products, etc.); the acquisition of concrete methods and of manufacturing procedures is as important as the concepts themselves; the government supports research and keeps technology transfers under control in order to protect both industry and national security. Finally, even more than in the 'university model', the mobility of specialists is often the only

way in which the least formalized aspects of technical know-how – such as empirical engineering 'tricks', or the experience of past failures – are passed on (see Chapter 10).

In the late 1940s, nearly all computer projects were carried on in universities and research centres. But, by the time France installed its first machines, it was already industry which produced most of the computers in the world. So one would expect the 'industrial model' of transfers to prevail, as was later the case in Japan. Indeed, in France, no 'first-generation' computer was built in public research institutions. Yet, in fact, both 'modes' were used. Their respective importance did not depend so much on the period analysed as on the personality and the corporate 'culture' of organizations. The history of the SEA illustrates this well.

The seeds of the SEA were first planted during a trip Raymond made to the USA in 1946. Raymond, who was at the time the scientific adviser for Sadir-Carpentier, a measuring-instruments manufacturer, had been sent abroad on an information mission. He visited the main US electronics laboratories, and brought back with him the document which is generally considered as the foundation of modern computing, the report written by John von Neumann, Arthur W. Burks and Hermann H. Goldstine (1946), which gave food for thought to the SEA engineers, and became a key element in the company's long-term product policy.

From the beginning, the SEA had a well-stocked library, which provided its personnel access to the most up-to-date specialized publications (such as the collection of the MIT Radiation Lab, etc.). A survey of the proceedings of the various computing and automation conferences organized in Europe in the 1950s (CNRS 1951; National Physical Laboratory 1954) shows that the SEA was regularly represented.[5] Moreover, the SEA, aware of the value of the scientific resources existing in higher education, employed consultants or 'mathematical advisers' from the academic sphere. The latters' contributions (for instance the 'BCH' error-correcting codes, invented by A. Hocquenghem, a professor at the Conservatoire National des Art et Métiers) were valuable in fields such as programming. Last but not least, the SEA sent several of its engineers for visits and training periods in foreign university laboratories, where they learnt skills not yet available in France: a number of the first French computer scientists were therefore trained in Boston (Massachusetts), in Manchester, and in Cambridge, where the first computer-programming manual was published in 1951. Concepts such as microprogramming developed by Maurice V. Wilkes in Cambridge

and inspired by the EDSAC machine, influenced the design of the first SEA computers.

Nevertheless, the SEA resorted to more typically 'industrial' methods of technology transfer, these being the acquisition of licences, components and even parts of machines. An example of this is the development of magnetic drums for the first SEA computers. The SEA, which was designing drums of its own, still needed to acquire a licence on phase modulation from the British National Research Development Corporation (NRDC), which held patents for this process. The magnetic drum of the large CUBA computer was even directly purchased from Ferranti Ltd, who had a certain experience in this matter. Later on, the SEA signed an agreement with Control Data Corp. to manufacture magnetic peripherals.

The telecommunications sector was a major source of technologies and of competences for the first computers (e.g. delay lines, binary circuits, pulse counters). Indeed, the SEA recruited many engineers from the telecommunication industrial-research organizations, such as CNET, LCT (the French subsidiary of ITT), etc.

The SEA played a pioneering and influential role in the development of the French computing industry. More than any other entity, it exploited the entire range of the technology-transfer modes. In fact, this enterprise fulfilled a double function in post-war France.

First, the SEA manufactured and sold products. Its analogue calculators were competing with those made by CSF, EAI and others. However, when it came to digital computing, SEA suffered little competition in the 1950s. The French electronics majors (CSF, Thomson, CGE, etc.) did not venture into this market before the early 1960s, unlike their foreign equivalents (Siemens in Germany, Ferranti in Britain, General Electric and Raytheon in the United States, Toshiba and Fujitsu in Japan); the market evolved then from an oligopolistic structure to a fiercely competitive situation – even with IBM's domination.

Second, the SEA was the first French institution to import, adapt, perfect and spread the corpus of knowledge which later became known as 'computer science'. This it did by designing novel computers and programming tools, by publishing scholarly and technical texts and by actively participating in higher education. Thus, the SEA was not only an industrial company, it also acted to compensate for the deficiencies in the French public-research system of the 1950s which, unlike its European and American counterparts, neither succeeded in building any computer, nor initiated many technology transfers in this field.

THE COMPAGNIE DES MACHINES BULL

The Compagnie des Machines Bull was founded in Paris in 1931, to develop the patents on punched-card machines taken out in the early 1920s by Fredrik R. Bull, a Norwegian engineer. It was headed and owned by a group of businessmen, notably Georges Vieillard, who served as the general manager until 1962, and by members of the Callies family, owners of the Aussedat paper mills, and related to the Michelins. Aussedat supplied the cards necessary for the 'accounting and statistical machines' produced by Bull. Starting with a workshop of 50 people in 1931, the company had conquered a respectable share of the French market, in spite of the competition from well-established multinationals like IBM and Remington-Rand. This was a modest market, in fact, since only big businesses and public administrations could afford the expensive punched-card office equipment (Mounier-Kuhn 1989, 1990a).

1948 was a crucial year in the history of Bull. The company's rapid growth and its increased capital needs led to its introduction on the stock exchange. Bull equalled IBM on the French market, and then launched itself on to an international expansion scheme. Last but not least, its president decided to create an electronics laboratory in order to counter the competition.

Modern components, conservative design

Four main factors shaped the innovation process and the appearance of new products in the company during the 1950s. First, the internal logic of development of office machines, calling for new technologies such as electronics; second, the desire to conquer new markets; third, the products unleashed by competitors, mainly IBM (in fact, this factor partly coincided with the first two); and, finally, the need to produce a small number of models, to use them as widely and for as long as possible while adding the necessary improvements and variants, in order to cover the costs of R&D and production. These combined factors are to be found in each product developed by Bull at the time.

The event which convinced Bull to create an electronics laboratory was apparently the impressive sequence of commercial announcements made by IBM in 1948: the electronic tube calculator model 604, the IBM 402 tabulator, the IBM 082 electronic sorter. These products first appeared on the American market, then in Europe two or three years later.

A punched-card system was ordinarily composed of a tabulator, a sorter and a card-punch (the 'holy trinity' in professional jargon), to which several 'auxiliary machines' could be added – calculators, reproducers, etc. It was a set of devices whose overall performance was only as good as the performances of the weakest link. The innovation aimed at improving the processing speed (that is, the ability to process large volumes of data-cards), as well as the reliability of the machines.

Since 1932, Bull had been producing a tabulator whose printer unit printed 150 lines per minute, which made it by far the fastest on the market. This speed was equalled in 1949 by the competing tabulators (IBM 402). But it was a theoretical speed, often handicapped by the slowness of two other machines, the relay calculator and the sorter. The manufacturers thus endeavoured to improve them by replacing the electro-mechanical relays with electronic circuits. In 1950, the founder of the Bull electronics laboratory, B. Leclerc, and his collaborator H. Feissel went to the United States, where they spent three weeks at Remington-Rand-Univac, which had just signed a cross-licence agreement with Bull. When they returned, they designed the 'Gamma 3' calculator, put on the market in 1952, along with an electronic sorter.

The success of the Gamma 3 (1,200 units sold in ten years) was one of the reasons for the spectacular expansion of Bull in the following decade. It was an excellent machine, superior to the IBM 604, thanks to its logical design and to its technology (semiconductor diodes). However, like the IBM 604, the Gamma 3 was an electronic calculator, not a computer; the program was not stored internally, but 'cabled' on a plug board similar to manual telephone switches – the usual 'programming' technique of punched-card machines. In fact, the Gamma was designed to be the calculating unit of the Bull tabulator, and to accelerate its processing speed; this system became the top of the Bull products. In the process of technology transfer, the Bull engineers had had access to excellent sources, Univac (inventors of the electronic computer) and also the US National Bureau of Standards. But the strong 'corporate culture' of the company, based on punched cards and plug-board programming (*la mécanographie*), only allowed for innovations which could fit in this family of machines.

For several years, the CMB remained rather indifferent to American and British breakthroughs in modern computing: the stored-program computers' prohibitively high prices seemed to make them unattractive to the French market; besides, they seemed to be essentially

scientific devices, as opposed to the business machines. The Bull engineers developed 'Mathematical' and 'Programme Par Cartes' (card-programmed) versions of the Gamma 3, which permitted Bull to break into the scientific market. But this remained marginal for Bull, compared to the banking sector which alone represented one third of its clientele.

Consequently, Bull was taken aback in 1955, when IBM presented and started producing in its French factory the IBM 650 drum computer, announced in the United States in 1953. The Bull engineers hurriedly replied by developing a memory 'extension' and a magnetic drum connected to the Gamma 3. Programming this system was difficult, even by the standards of the day. But in the end, the resulting Gamma ET (*Extension Tambour*/drum augmented) was a success. More than 120 were sold or rented, 40 of which were exported, so that the Gamma ET became one of the very first computers in history produced on a truly industrial scale.

Which products for 1960?

Once the Gamma ET was released, Bull had in place by 1956 a complete line of products, from classical punched-card machines to 'first-generation' computers – a line which would later be baptized 'Série 150' in reference to its printing speed. A question naturally arose: what products would it need to introduce around 1960, in order to continue the company's expansion?

The machines' improved performances had revealed a new bottleneck, caused by the punching of millions of cards supporting data. This was a fastidious manual chore, liable to perforation errors, requiring entire rows of employees (punchers, checkers, etc.) drudging in workshops which could reach impressive proportions. In brief, the very type of task in which gains of productivity seemed indispensable. Modernizing data-input techniques thus became a priority objective for the engineers. Various solutions were adopted.

The manual perforation of cards was replaced with pencil 'markings'. The cards were then perforated by the machine itself, which would read the marks by means of an electrical or photoelectrical process. The IBM mark-sensing and the Bull *photolecteur* were devised for this purpose in 1950.

An accounting machine, such as Logabax, NCR, Flexowriter, etc. was connected that directly printed calculations and tables (like a typewriter), with a teletype tape punch. The perforated tape was then introduced into a machine which would 'transcribe' its content on to

cards. This automation of card perforation reduced the rate of errors. It also at last combined the advantages of both accounting machines and punched cards: the first directly printed information on paper, and the second conserved the data for other operations (e.g. sorting, collating, etc.) or for periodic, repetitive processing (e.g. monthly payrolls). Finally, perforated tape was much lighter and less bulky than punched cards. The branches of large enterprises could therefore decentralize their accounting by keeping their daily logs on paper and mailing the corresponding tapes to the head office, which would convert them into cards and process the latter on tabulating equipment. Similar systems could be organized for small independent businesses, which generally had accounting machines but could not afford punched-card machines; they could now entrust their perforated tapes to a processing service bureau equipped with tabulators. It was even possible to avoid mailing perforated tapes, as their contents could be transmitted electrically by telex lines. All of these advantages, at once technical and organizational, provided by such 'teletapes' systems, offered not only a solution to the problems caused by card perforation, but also gave their inventors means to conquer new markets. Several manufacturers brought out such systems in the second half of the 1950s. The Bull engineers devoted hundreds of hours to perfecting devices based on this principle.

At the same time, it became possible to get a machine to read printed characters. This principally interested banks, Bull's main market, which had to deal with a continually growing flow of cheques. In response to an international call for bids, Bull created the CMC 7 (*Caractère Magnétique Codé à 7 barres*), which simultaneously allowed magnetic reading by the machine and direct optical reading by a human user. Adopted in 1963 by most European banks, the CMC 7 is still used to code our cheques.

The last solution consisted in completely replacing the punched cards with magnetic storage: a magnetic tape reel 30 cm in diameter could store as much data as several cubic metres of punched cards, and delivered it fifty times faster. But this technique was still marginal in Bull's environment (i.e. France) in 1956. It was less 'user friendly' and was not as tangible as a card, which even an operator with basic training could easily decode; it still left something to be desired in terms of reliability. France was behind in the field of magnetic recording, which was dominated by Germany – through the invention of the *Magnetophon* tape-recorder in the 1930s at IG-Farben and AEG – and the Anglo-Americans who had developed the magnetic drum and Univac 1 computer with magnetic tapes in 1951. Finally,

magnetic tapes were expensive and their use was only justified with computers. These resolved all the technical problems inherent in business machine technology (eradicating the need for sorters, 'interpolators' and for separate high speed calculators) – but at a very high price.

After having modernized calculators, sorters and card punching, it was time to take care of the 'central processing units' of the punched-card equipment. Bull, like its competitors, was conscious that the generation of tabulators conceived in the 1930s and 1940s needed a replacement. Two products resulted.

The short-term solution was *l'Ordonnateur* (1957). It was an electronic dispatcher which, by connecting two tabulators (or other machines) to the Gamma ET, doubled the speed of punched-card reading and of paper printing. With it, the old 150 series achieved its maximum extension. About twenty *Ordonnateurs* were produced.

The long-term solution was the 300 TI project, operating at 300 cycles per minute. It was a punched-card system designed for business applications, and presented, at once, a modernized equivalent (transistors, doubled input/output speed) of what the 150 series had become in twenty years of innovations and of successive extensions: a set of modular devices that could be combined together in order to achieve the desired systems, according to the clients' evolving needs. It incorporated some of the elements developed in the Bull electronics laboratory. But its main parts were electro-mechanical (i.e. relays). The program was cabled on a plug board, with the potential for stored programs in certain configurations. Programming the 300 TI was difficult, its tuning was delicate and costly, and so was its maintenance; the cost price was therefore high. Announced in January 1960, the 300 series was a technical and commercial failure (150 units marketed, with a high rate of returns before full payment) and its production was stopped after two years.

In fact, the 300 TI was not a coherent machine; it was a contrivance of heterogeneous elements, from which the client was invited to choose the ones which best suited his or her purposes. Bull's marketing compared the 300 TI to a Meccano set, or to a car which, at the buyer's whim, could run on four, five or six cylinders, on a variable number of wheels, etc. This product clearly showed that Bull, hesitating as to which techniques to employ, could not define a mid-range machine but left this to the customers: the market took care of the marketing. This approach was perhaps not intrinsically wrong. In this case, the uncertainty which it signalled was coupled with serious technical deficiencies, which revealed beyond a doubt

that punched-card technology had reached the limits of its potential. The clients preferred the products of their competitors, notably IBM's computer model 1401.

Another of Bull's major preoccupations was that of conquering the small-business market, which was, until then, the exclusive domain of accounting-machine suppliers (Logabax, NCR, etc.). We saw above that the development of 'teletapes' was a step in this policy. In 1957 Bull signed a commercial agreement with the Confédération des Petites et Moyennes Entreprises, in order to create, with the support of accounting experts, a nationwide network of data-processing service bureaux. The engineers endeavoured to develop down-market versions of the punched-card machines. Bull proposed minimal configurations of the Série 150 (which had already largely paid off) and presented a 'TME' series in 1961.

Among these multiple orientations, what place should be given to computers in Bull's future product lines? In the company's view, the stored-program computers were, by nature, big machines, meant either for scientific research or for large companies which could afford both the machines and the teams of expensive programmers: banks, insurance companies, railways. One of the specific applications of computers was that of giving mathematical assistance to decision-making and operational research, which concerned primarily big-business managers and the army. It was for this type of client that Bull, in 1956, launched the Gamma 60 project. This would be a large computer, 'with capacity and speed a hundredfold superior to the Gamma ET's', but 'remaining on a European scale from the point of view of price'.[6] Bull counted on the Gamma 60 and on the prestige it would shed on its other product lines to sustain the company's expansion and to attack the most difficult market: the United States.

The development of the Gamma 60 happened to be more arduous, more costly and longer than expected. The public announcement, in the spring of 1957, forecast delivery by October 1959. In fact the prototype was not ready until 1960. It would be still another year before the machine became operational for the first clients.

There were several reasons for this delay. The Gamma 60 was a risky project, because it was innovative on every level at once: components (transistors and ferrite cores), architecture (multi-processor), size of the machine (a very big computer, whose designers did not even have an experience on medium-size machines), peripherals (magnetic-tape units, bought from an American supplier, but which still had to be adapted and customized), and symbolic

programming. All this was new for the Bull engineers. Considerable effort was needed, not only to learn and master all these domains, but also to control their interactions. Moreover, the development of an operating system and of application programs happened to be very poor. The result was disappointingly low sales, which were far from covering the development costs (80 million francs). While several Gamma 60s were exported (to Credito Italiano, Belgian R.T.T. and Mitsubishi), part of the prestige that Bull had counted on was lost when certain customers, like Gaz de France or the Assurances Générales de France, discouraged by the difficulties encountered in installing and programming the machine, cancelled their orders. Of the nineteen Gamma 60s built, only about a dozen remained in service – some of them until the 1970s.

Decision-making under high uncertainty

Bull thus found itself, in 1960, with a catalogue showcasing:

a commercially disappointing Gamma 60;
a 300 TI series which missed its target, the heart of the market;
a Gamma 3 whose technology would soon be obsolete; and,
a traditional '150' series which kept the company afloat, but could not be expected to do so much longer: the 1963 annual report laid stress on 'the decline of electromechanical equipment', for which orders grew only by 8 per cent.[7]

Bull, having no home-made product able to resist the IBM 1401 *blitzkrieg*, finally resorted to acquiring a licence for the RCA 301 computer, which it distributed in France as the 'Gamma 30'. It was not until the end of 1963 that Bull was in a position to present its own small computer, the Gamma 10. The Gamma 10 was a commercial success, but it arrived too late. Bull was in the red with an 85-million franc loss, without any hope of recovery in the short term. A series of political and industrial manœuvres ended in 1964 when General Electric took control. Bull had been the victim of a growth crisis that came at a time when its products were uncompetitive. How did the product policy come about which resulted in this situation?

We can immediately set aside the common explanation that the company ignored the customers' needs and made an error in marketing assessment – a frequent weakness in the French industry, where selling was traditionally undervalued. This was not the case at Bull, which had correctly foreseen the necessity of simultaneously offering a large computer for the big customers, a medium-sized machine

aimed at the mainstream market, and a well-tried, mass-produced line, to conquer the small-business clientele. The problem was not located 'downstream' – at the time, Bull was an enterprise of commercially quite aggressive 'sellers' – but 'upstream', and concerned its ability to analyse technological developments and to use scientific resources. Perhaps a good example of this orientation is given by a simple fact: as the company grew to more than 10,000 employees, and traditional means of internal information were no longer sufficient, a quarterly *Bulletin de liaison commerciale* was launched, starting in 1956; however, Bull never created a similar journal for its R&D personnel, unlike CSF or Thomson in France, ICT in Britain, not to mention IBM.

Pure ignorance can not be alleged, of course. The founders of the Bull electronics lab had spent several weeks at Univac in Philadelphia in 1950, and seen the first Univac computers being tested. But Bull was highly uncertain about the evolution of the technologies. How was it possible to distinguish, in the announcements of the competitors, between bluff and credible technical information? Were the punched cards to be really phased out? Many users denied such a perspective. What would be the programming methods in the future? Burroughs was introducing an electronic, plug-board programmed calculator, whose input/output functions were performed by a punch-tape accounting machine; Univac itself, the inventor of the business computer, announced the Univac 120 and the punched-card Calculating Tabulator. Besides, how was one to choose the best technologies and the most efficient and reliable components? Should Bull opt for magnetic amplifiers, as its partner Univac-ERA once did, or prefer transistors? The first were more reliable, the second were faster but more expensive.

IBM, whom Bull was cautiously watching, covered the entire spectrum; it produced large and medium computers, new tabulators, various electronic calculators, mini-equipment for the small businesses, military devices, etc. The world leader had sufficiently solid backing to launch many projects at the time, and the most costly ones were financed by the Pentagon. But Bull was thirty times smaller and was not particularly supported by the government, at the time. Thus, caution advised to extrapolate on the basis of traditional punched-card know-how, which the staff had mastered, whose production was within Bull's means, and for which demand grew ceaselessly. Moreover, selling punch cards was extremely profitable.

Managing the input of technical information

How was it that, by 1956, Bull's management had not succeeded in reducing the uncertainty surrounding their decision-making policy? Answers can be traced to their attitudes regarding the acquisition of information on the scientific and technical state of the art. Of the different methods of technology transfer, Bull resorted to the 'industrial' mode, not to the 'academic' one, unlike SEA which acted from the beginning in a 'science-based industry' spirit.

The innovation race and the growing R&D costs forced Bull to intensify its research effort. The budget of its R&D department reached 12 per cent of the company's revenue, with a staff of 900 persons in 1960 (5 per cent of the employees). However, this effort remained insufficient, according to the managers themselves. While the Bull engineers were second to none in electro-mechanical devices, in plug-board programming and in electronic circuits, the firm seriously lacked competences in mathematics, in magnetism, and in solid state physics. And yet, this knowledge was available in academic research. The Institut de Mathématiques Appliquées de Grenoble (IMAG), built up since 1948 by Professor Jean Kuntzmann, was the first computing sciences centre in France, and had a tradition of cooperating with industry. The Laboratoire d'Electromagnétisme et de Physique du Métal, headed by Louis Néel, had an international standing in fields such as magnetic layers and ferrites (Néel was awarded the Nobel prize for his theory on ferrite material); it worked for the army and for various companies, including IBM. At the Ecole Normale Supérieure in Paris, the laboratory headed by Yves Rocard had studied semiconductors since 1945, and one of Rocard's assistants created the transistors department at CSF (now Thomson-CSF). Across the Channel, the computer pioneers in Cambridge and in Manchester welcomed trainees and visitors from abroad. But Bull did not take advantage of these resources.

While the company had acquired a commercial position on the scientific market, this was rather limited and recent and hardly included research collaborations before the end of the 1950s.[8] When Bull engineers lectured at higher-education establishments, their teaching was essentially concerned with operational research, thus reflecting, at the time, the company's almost exclusive business orientation.

Neither Bull's directors, nor its engineers (with some rare exceptions) were in the habit of using scientific resources from universities.

Bull did not maintain systematic, scientific monitoring, and was conspicuously absent at the first academic computer symposia held both in France and abroad (including Cambridge 1949, Paris 1951, Manchester 1951, National Physical Laboratory at Teddington 1953 . . .). Unlike other companies (SEA, CSF, IBM), Bull did not take part in CNRS committees (Centre National de la Recherche Scientifique).[9] The old Bull engineers are, in retrospect, quite aware of this problem and describe 'a firm closed in on itself' that 'did not suspect that it might benefit in any way from basic research'.[10]

This attitude slowly changed, beginning in the late 1950s; Bull's management became conscious of the need to cooperate with the scientific community, and of the importance of this market. The first reason for this evolution was that Gamma ETs were installed in universities, and scholars developed programming tools for them; a 'Gamma ET Users Group' was created in 1958. Then, mindful of the Gamma 60's deficiencies, Bull's directors asked the Grenoble mathematicians to develop software for this machine, and even offered a Gamma 60 for free to the university; unfortunately, the latter had other priorities and deadlines to meet, and turned down the offer. They ended up buying SEA and IBM computers.

In most advanced countries, military research contracts have greatly contributed to the initial development of the computer industry. Working for the army had several advantages. In addition to their financial resources, the military could help their suppliers gain access to the latest technical information, in order to obtain state-of-the-art products. Bull neglected this particular market. The French army finally chose IBM to develop its missile guidance and radar signal processing systems.

The 'closed in on itself' attitude of Bull, its principle of technical self-sufficiency, was exemplified by the management's constant refusal to send the engineers out on missions, in spite of their increasing demands to visit Univac and other places where computing was being developed. Even the trips made by Bruno Leclerc, the director of the electronics laboratory, to the United States (1950) or in England (1953), were exceptional. Such trips were reserved for the upper management. The latter could not acquire much more than commercial information, and were unable to 'descend' to the level of new technologies under development, which they were not competent enough to assess.[11]

Caution and even myopia led them to select information which complemented and comforted their own orientations, and to

underestimate that which did not. In June 1955, Joseph Callies and Vieillard thus summarized their recent voyage to the United States.

> Through our numerous contacts [. . . we were able to] know about [our competitors'] actually marketable achievements, and to distinguish these from projects which will not be available in the near future, in spite of premature publicity which somewhat upset some people in France.
>
> (Bull Rapport 1954)

The projects described as 'prematurely publicized' were very likely the big IBM 700 series computers, just marketed in the United States and which arrived in France two years later.

In 1956, the same managers defined the company's policy:

> We have considerably augmented the R&D budget. . . . Our effort will be concentrated first of all on developing new devices connectable to the existing machines, in order to improve their capacity or performances. (Examples quoted: the magnetic drum and the memory extension connectable to the Gamma 3)
>
> (Bull Rapport 1955)

These declarations can be understood this way: Bull spared its clients, more than IBM did; the gradual evolution of the machines through successive 'extensions' was preferable to creative destruction and to the products' technical obsolescence. The then widespread belief in a progressive evolution led Bull's managers to underestimate the brutality of changes which were now made possible by the simultaneous maturing of the main 'second-generation' components. As Bull's export director explained later: 'Technological progress came faster than we had expected' (Chargueraud 1963).

Along with this caution, there was an evident desire to reassure oneself. The *Bulletin de liaison commerciale* described the IBM 305 RAMAC (the first magnetic disk, introduced in September 1956) with a commentary meant to minimize the importance of this machine. No question whatsoever was asked in this paper, concerning the future potential of the new system (Bull Bulletin/1956).

The Bull story exemplifies a well-known phenomenon: while 'technology push' leads firms to develop radical or major innovations, 'market pull' usually induces them to promote incremental innovations (Steele 1975). At Bull, there was a considerable imbalance between information from the scientific and technical world, and information from the commercial market. The predominance of 'market pull' over 'technology push', and the very partial perceptions

which resulted, explain why the company entangled itself in heavy investments in tabulating machinery.

Could Bull's crisis be also attributed to organizational problems? IBM's decentralization, imposed by Thomas Watson, Jr in 1955 after his father's death, was one of IBM's factors of success. In spite of its size, IBM thus became more able to perceive the fast changes of technology and market, and to react promptly. Was Bull centralized? It is difficult to answer, since there was no formally organized structure. On the one hand, Vieillard was an energetic and autocratic leader, who firmly held the company's reins in hand. He probably maintained the vagueness of the hierarchical structure, because this allowed him to exert his control at all levels, including minor business and commercial details. For instance, engineers could not know the factory price of the machines, or the budget they could count on to fulfil their missions. There was no direct communication between the commercial staff and the research engineers.

On the other hand, once the green light on a project had been given, R&D engineers enjoyed a great amount of freedom in their work. Neither Vieillard nor Franklin Maurice, who had been the director of R&D since 1942, knew much about electronics; they had to trust their engineers. Therefore, at the most crucial moment, none of the company's managers was familiar with the new technologies, with their requirements or with their potential.[12] The situation was propitious for the engineers to design a technical masterpiece without much consideration for the market requirements: this was the Gamma 60.

In a paper about 'Managerial enterprise and competitive capabilities', Alfred D. Chandler, Jr (1991) described the three elements which have distinguished the leading companies in the world through our century:

concentration of production capacity to achieve economies of scale and scope;
creation of an international commercial network;
establishment of a managerial hierarchy to coordinate production and distribution, to allocate resources, and to produce and process standardized information (see Chapter 7).

During the 1950s, Bull made the first two sets of investments, as it multiplied its factories and created subsidiaries or commercial agencies in 42 countries. But it did not really shift from a small-business style organization[13] to a modern form of management.

Despite its strong growth, did the R&D at Bull lack financial

means? The French firm had little room for manoeuvre, when one keeps in mind that IBM's R&D expenditure alone was equivalent to Bull's total revenue . . . But one must also wonder about the way resources were used, about investment choices and research orientations. The means devoted to develop the *Ordonnateur*, the 300 TI series and other incremental improvements in tabulating machinery, were diverted from the mainstream of innovation and were not even profitable in the short term. In situations of high technical uncertainty, the risk for a company lies between two extremes: either being over-audacious, by launching an excessively innovative project, leading to problems in terms of feasibility or marketability; or being over-cautious, by clinging to outdated systems. Between 1956 and 1960, with the Gamma 60 and the 300 TI series, the Compagnie des Machines Bull made both mistakes at the same time.

Later on, struggling to extricate itself from its crisis, Bull went to the Radio Corporation of America in order to distribute the RCA 301 and to benefit from RCA research in electronics. Then it chose to fall under the control of General Electric. It is interesting to note that these two American companies gave up computer manufacturing a few years later (1970), unable as they were to compete successfully against IBM. In the early 1960s, when it came to choosing strategic alliances, Bull seemingly suffered from a lack of information about the innovative potential of its partners, just as it had lacked information about the evolution of computer techniques in the previous decade.

CONCLUSION

The history of Bull and of the SEA, from 1948 to the early 1960s, illustrates a well-known theme: the difficulties that established organizations have in severing ties with their 'traditional' behaviour, with their material and intellectual investments, in order to take complete advantage of technological revolutions; and the role played by small, new enterprises in radical innovations. However, this opposition does not fully account for this piece of history. Restrictions and constraints in the firms and in their environment tended to limit the possibilities of strategic choices. In the 1950s, Bull was not strong enough to venture into the US market. The markets where Bull expanded – mostly continental Europe and the French colonial empire – were technically behind Britain and the United States and favoured less innovation.

The resources available in France were rather limited, in terms of managerial competence and scientific expertise. In the mid-1950s,

the owners of Bull, aware that the company's management needed fresh blood, tried to recruit a general secretary and a new research director among the rising generation, but they failed. The most serious deficiency, as we already mentioned, was the failure of the French public-research system, which did not build any computer in the pioneer era, and thus had no specific computer know-how to offer to the industry before 1960; an essential source of information was lacking in France.

Facing these constraints, Bull and SEA could have reinforced each other by working together. Their complementarity is obvious, as regards their products, their markets, their competences and the resources which they used. Indeed, they started a collaboration in 1950. Unfortunately, the working meetings soon led both partners to conclude that their approaches were too different, and their product policies, incompatible.[14] The failure of this attempt was certainly one of the most harmful events in the history of computing in France; the industry missed an opportunity which never repeated itself. Afterwards, the relationship between Bull and SEA deteriorated. A new agreement, signed in 1963 under pressure from the government, ended up in court. Only after 1976 did the French computer manufacturers achieve their unity, but meanwhile they had been through avatars (Plan Calcul, etc.) which deeply altered them.

NOTES

1 I want to express my thanks to the University of Reading Business History Unit, to the British Council for its financial support, and to the Groupe Bull whose historical archives are invaluable.

2 The proceedings of the two conferences on the history of informatique in France amount to 1,600 pages, and some of the papers have been published in the *Annals of the History of Computing* since December 1989.

3 The history of SEA was summarized by F.-H. Raymond (1988, 1989).

4 The problem of the transition from the technical market to the business market is typical in the computer profession. It is faced, nowadays, by companies like Hewlett-Packard, Sun and others, whose case could be compared with SEA's, on a different scale.

5 For example, SEA was represented at the 'Colloque international du CNRS' in Paris in 1951. The National Physical Laboratory conference, March 1953, was attended by the three SEA engineers, J. Albin, R. Dussine and P. Namian. SEA staff also participated at the 'Congrès sur les procédés d'enregistrement sonore et leur extension à l'enregistrement des informations', Paris 1954.

6 The quote is from a speech by J. Callies at the Paris *faculté des sciences* 19 December 1956 (Bull Bulletin/1957).

7 Bull Rapport/1963. Besides, the factory prices of conventional equipment

(card readers and electro-mechanical printers) decreased at a fast rate until the early 1960s, then at a much slower rate, as illustrated in Flamm 1987: 26, fig. 2.4.

8 Norberg suggests that punched-card machines began to be used for scientific computing around 1930 in the United States, then in Great Britain (Norberg 1990). In particular, IBM had settled a permanent relationship with Columbia University in New York; in the late 1940s 'Big Blue' (i.e. IBM) hired scientists and created its Applied Science and Pure Science divisions, which played a decisive role in IBM's investments in computers. In France, Bull machines were first used during the Second World War for statistics in social sciences, then in 1947 at the aeronautics research office, ONERA.

9 The General Mechanics and Applied Mathematics Committee, created in the late 1940s, was the cradle of the Computer Sciences Committee at the CNRS (Baron and Mounier-Kuhn 1990).

10 Private interview with Bruno Leclerc, 1989.

11 Bull had a permanent correspondent in New York, Fred Ostheimer. Ostheimer, a former car-parts manufacturer who had become an American agent of the Michelin group, could not do much more than to forward the commercial documents published in the United States to Paris.

12 Bull's managers were acutely aware of this problem. In 1956, they tried to hire a Navy engineer who was an expert in digital control systems, P. Davous. Davous, who was in his early thirties, refused to become director at once, and he entered Bull as one of the Gamma 60 project engineers.

13 I avoid using the expression 'family business' as opposed to 'managerial company'. Indeed, Bull belonged to the Callies family and, moreover, about twenty people in the hierarchy were related to the Callies (including, for example, the director of the electronics lab, Leclerc). But, on the one hand, the main decision-maker at Bull, Vieillard, did not belong to the Callies 'tribe'; on the other hand, some members of the family acquired a serious education in management and held senior positions after the takeover by General Electric and well into the 1970s (for instance, Olivier Callies, a graduate from the Ecole des Hautes Etudes Commerciales, became financial director at Bull-GE and then at Honeywell-Bull) (see Mounier-Kuhn 1990b).

14 It seems that collaboration has been difficult everywhere between punched-card machine manufacturers and electronics companies, as shown by the examples of Ferranti, Powers-Samas and BTM in Britain, and the Univac-ERA-Remington Rand conglomerate in the United States.

BIBLIOGRAPHY

Archival sources

The material listed below, including an in-house journal and annual reports, is from the Groupe Bull archives, Nanterre, France.

Bull Bulletin/1956 *Bulletin de Liaison Commerciale* 2, 1956, p. 25.

Bull Bulletin/1957 *Bulletin de Liaison Commerciale* 3, February 1957.
Bull Rapport/1954 *Introduction au rapport sur l'exercice 1954*, AG du 28 juin 1955.
Bull Rapport/1955 *Introduction au rapport sur l'exercice 1955.*
Bull Rapport/1963 *Introduction au rapport sur l'exercice 1963*, pp. 40, 42.
SEA/1949 *Exposé sur la structure logique des machines à calculer universelles*, 22 November 1949, FHR/DB. This is an SEA internal report from a private collection.

References

Aspray, W. (1986) 'International diffusion of computer technology, 1945–1955', *Annals of the History of Computing* 8: 351–60.

Baron, G.-L. and Mounier-Kuhn, P.-E. (1990) 'Computer science at the CNRS and in universities: a gradual institutional recognition', *Annals of the History of Computing* 12: 79–87.

Bashe, C. J., Johnson, L. R., Palmer, J. H. and Pugh, E. W. (1986) *IBM's Early Computers*, Cambridge, MA: MIT Press.

Campbell-Kelly, M. (1982) 'The development of computer programming in Britain (1945–1955)', *Annals of the History of Computing* 4: 121–39.

—— (1990) *ICL: A Business and Technical History*, Oxford: Oxford University Press.

Caron, F. (1985) *Le Résistible Déclin des sociétés industrielles*, Paris: Perrin.

Casanova J.-C. and Lévy-Leboyer, M. (1991) *Entre l'état et le marché: l'économie française, des années 1880 à nos jours*, Paris: Gallimard.

Chandler, A. D. (1991) 'Managerial enterprise and competitive capabilities', *Business History* 34: 11–41.

Chargueraud, M. (1963) 'Quand la France exporte des machines électroniques', *Moniteur du Commerce International* 291.

CNRS (1951) *Les Machines à calculer et la pensée humaine*, Paris: CNRS.

Conservatoire National des Arts et Métiers (1990) *Actes du 2e colloque sur l'histoire de l'informatique en France,* Paris: CNAM.

Flamm, K. (1987) *Targeting the Computer*, Washington DC: Brookings Institution.

INPG (1988) *Actes du colloque sur l'histoire de l'informatique en France*, Grenoble: INPG.

Mounier-Kuhn, P.-E. (1989) 'Bull – a worldwide company born in Europe' *Annals of the History of Computing* 11: 279–97.

—— (1990a) 'Bull: 70 ans de traitement de l'information', *Actes du 2e colloque sur l'histoire de l'informatique en France*, Paris: CNAM.

—— (1990b) 'Entre technique, science et marchés: la Compagnie des Machines Bull devant la révolution informatique', *Actes du XVIIe congrès ICOHTEC*, Paris: CNAM.

National Physical Laboratory (1954) *Automatic Digital Computation*, London: HMSO.

Norberg, A. (1990) 'High-technology calculation in the early 20th century: punched cards machinery in business and government' *Technology and Culture* 31: 753–79.

Raymond, F.-H. (1988) 'La SEA: une aventure qui termine mal', *Actes du colloque sur l'histoire de l'informatique en France*, Grenoble: INPG.
—— (1989) 'An adventure with a sad ending – the SEA', *Annals of the History of Computing*, 11: 263–77.
Salomon, J.-J. (1986) *Le Gaulois, le cow-boy et le samouraï: rapport sur la politique française de la technologie*, Paris: Economica.
Steele, L. W. (1975) *Innovation in Big Business*, New York: Elsevier.
von Neumann, J., Burks, A. W. and Goldstine, H. H. (1946) 'Preliminary Discussion of the Logical Design of an Electronic Computing Instrument', June 1946.

7 Economic perspectives on business information[1]

Mark Casson

INTRODUCTION

Conventional economics focuses on decision-making under conditions of scarcity. The decision that is taken reflects the information that is available. In this context accurate and relevant information is a resource, since by improving the quality of a decision, information helps to conserve other resources.

Within society the decisions of different individuals need to be coordinated so that conflict is avoided. The most obvious way to do this is for individuals to form provisional plans and communicate these to each other. They can negotiate over whether one individual will modify his plan if someone else will modify theirs. This provides the foundation for the market system.

But the economic issues are not confined to the role of information in the market system. There are also important issues concerning the construction and use of information itself. To begin with, effective communication of information requires some agreement on what the strings of symbols that make up the messages are supposed to signify. There is, therefore, a standardization issue, relating to the use of a common language. There is also the question of the economy of the language itself. How many different concepts are required to express intended meanings clearly? Too few concepts will cause ambiguity, whilst too many will make the language difficult to learn. This economy issue also affects communication. How much detail needs to be given in a message for example? Can information on individual subjects be summarized by reporting aggregate information for the subjects as a group? Finally, there is economy in decision. How wide a range of different options should be considered and, for each type of option, how finely grained should the individual options be? For example, in negotiating over price, should the range of possible

prices be prescribed in advance, or left unbounded, and to what sort of figure should prices be rounded – the nearest pound or the nearest penny?

Negotiation involves an implicit recognition of the rights of the other party. If a person does not recognize someone else's rights they may as well impose their will by force if they can. Society cannot really function peacefully without mutual recognition of rights. This also calls for standardization: a person's rights need to be recognized by everyone in society and not just a few family or friends, for otherwise everyone will have to classify prospective partners as 'friend or foe' before negotiations can commence. A lot of information required by economic activity therefore concerns the allocation of rights – who has a legitimate entitlement to what. Ownership rights over physical resources are of particular significance where business information is concerned, although political rights have an important bearing on economic activity too. Other important rights relate to the ownership of money and financial claims, and intangible assets including information itself (see below, pp. 141–5).

When negotiations take place price acquires a prominent role. Prices summarize the inducements offered to people to modify their plans by substituting more of one thing or less of another (Hayek 1937). An agreed price harmonizes the trade-off made by one person with the trade-off made by another. Often people are not particularly bothered who exactly makes the substitution that releases resources for their own use. They can therefore invite other people in general to quote a price and accept the best offer. If everyone plays everyone else off against each other to obtain the best price then price will converge on a unique competitive equilibrium level.

There is no standard source in the economics literature where a theory of business information is systematically set out. Considerable progress has been made on several fronts in recent years, however. Information asymmetries between buyers and sellers are discussed in models of screening (Akerlof 1970) and signalling (Spence 1974). These models have important applications to insurance markets and professional labour markets. Modern game theory places great emphasis on the question of who knows what about whom, and what it is rational for them to conjecture about each other (Binmore and Dasgupta 1986). Then there is the modern theory of finance (Fama, Fisher, Jensen and Roll 1969) which has a lot of interesting things to say about market response to a flow of news items, and about how markets behave when insiders get to know the news before others.

This chapter is not designed as a literature review, however; its aim is rather to advance a set of hypotheses designed to explain historical trends in the growth of business information. These hypotheses are derived using the transaction-cost approach to economic institutions (Coase 1937). It must be recognized that the 'stylized facts' relating to the growth of business information are still being debated, so that some of the 'explanations' advanced below may have to be reconsidered in the light of new evidence. The structure of the chapter may be summarized as follows.

The argument begins by highlighting the duality of the relationship between business information and markets. Business information flows promote market activity, and thereby facilitate a division of labour in production. At the same time, the division of labour can be applied to the handling of business information itself. This division of labour is exemplified by the emergence of specialized intermediaries, such as wholesalers and retailers, within the market system.

A division of labour in information could, in principle, be supported by a market in information, in much the same way as a division of labour in production is supported by markets in products. Because information has scarcity value it is, in theory, just a commodity that can be traded like any other. But in practice it has certain distinctive features which raise its transaction costs – notably that bad information is difficult to distinguish from good. Because screening out bad information is very costly, good information often has to be given away, or is simply not traded at all.

When markets fail it is generally because transaction costs are high. Transaction costs, in turn, depend very much on the cost of information. Some markets require much more information than others, and this makes their transaction costs very high. The differential costs of information can therefore explain why some markets operate and others do not. It is because *information about information* is so costly to obtain that markets for information tend to break down.

The costs of information in a market context derive more from the communication of information than from its initial discovery. Trading partners may distrust the information supplied by other parties, or even fail to understand what is being said. It is shown how standardization may help to overcome problems of this kind.

The division of labour can be implemented within a hierarchical organization as well as through a market. There are, indeed, a number of insights into hierarchy that can be obtained from

the business information perspective, and these are summarized later on.

As information becomes cheaper it becomes less important to standardize the treatment of intrinsically different situations. This means that customary prices and forms of contract can be replaced by individually negotiated ones. The resulting growth of negotiation is in turn promoted if customs are redeployed from the regulation of price to the regulation of the negotiation process itself. Custom declines as a basis for suppression of markets, or intervention in them, and becomes the basis for negotiating contracts instead. This in turn reduces the impediments to change and undermines social stasis. Indeed the historical spread of economic liberalism can be explained in just these terms. The driving force has been the reduction of information costs through improved technologies of communication. The potential impact of further reductions in information costs is considered as the final issue. A summary of the main results concludes the chapter.

PRICE INFORMATION

To an economist, price is the most important kind of business information because it is price adjustment that drives the market process. Markets in turn promote the division of labour by allowing individual specialists to obtain through trade the consumer goods that they do not produce for themselves.

Price-making specialists

The division of labour is a general principle which applies to all activities including the handling of information (Babbage 1832). In a market system brokers and middlemen emerge to take responsibility for the supply of price information. These specialized price-makers cover their costs by either charging a fee, or setting a margin between the prices at which they buy and sell.

This division of labour has an important spatial dimension. Markets develop at central places, where customers can make direct comparisons of the prices offered by different middlemen. They can also inspect the characteristics and discover the relative prices of different kinds of product. The agglomeration of market activities therefore benefits the middlemen not only because they can share access to specialized facilities, but also because customers are attracted by the fact that they can discover a large amount of information on a

single trip. This is a special case of a more general phenomenon which also leads the head offices of organizations – and other information-handling units – to agglomerate in centres of market activity.

Interaction of price and quantity information

In a market system price information supplements quantity information, but does not supplant it. Quantity information is needed to specify how much each person supplies or demands. Without ascertaining the balance of supply and demand, the equilibrium price cannot be determined.

In the usual division of labour, specialists set prices and ordinary participants respond with quantity bids. This is also the case in abstract models of Walrasian competition, in which prices are set centrally by an auctioneer (Arrow and Hahn 1971). There are exceptions, however. For example, in a real-world auction, the price-setting initiative is actually devolved to the traders, with the auctioneer playing a relatively passive role. This can work well when the quantity is predetermined and the bidders are relatively well informed. A more radical exception is bilateral negotiation, in which each party typically responds to the other with a counter-quote; the quantity is either fixed, as in the case of the auction, or varies systematically according to the quoted prices.

Recording transactions

The price and quantity information so far described is used exclusively for the coordination of decisions. It relates to *offers to trade*. Once a contract has been agreed, or a managerial decision made, the status of the information changes, however. It now records an *obligation* – an obligation to a superior in the case of a management hierarchy, or a mutual obligation in the case of contract. Since one person's obligation is necessarily another person's right, the information is, equivalently, a record of the rights that have been established. Such records may be important evidence if there is a subsequent problem in implementing the agreement.

It should be noted that, unlike offers and counter-offers, rights and obligations have a distinctive moral content – which in most advanced economies is also backed by the force of law. This moral content becomes less important once the agreement has been successfully implemented, although it could be significant if the recipient's right of possession is subsequently challenged.

Once a transaction has been implemented, the information about it becomes mainly a *factual statement* that a certain quantity of resources, valued at a certain price, was transferred between certain parties. Such information is of potential interest to people engaged in other negotiations, and so the division of labour in the handling of information can be extended to support the specialized collection, recording and interpretation of such information.

THE MARKET FOR INFORMATION

This leads on to the more general issue of how information can be sold. The sale of information does not apply just to records of transactions; technological know-how is particularly important where the sale of information is concerned.

Quality assurance for information

When information is to be sold, its quality is generally a far more important issue than its quantity. No information can guarantee its own truth. Information offered for sale is really just a claim, whose relevance is urged with apparent conviction by the seller in order to raise its market value. There is a strong short-term incentive for people to make up information if they believe a demand for it exists. The market for information can easily become flooded with worthless products, and buyers who cannot discriminate will therefore withdraw once they realize the nature of the problem.

Quality problems are common in other areas too. The usual solution is for the seller to offer the buyer a free sample to try it out. There is, however, a difficulty with information, namely that it is a satiation good. The information, once supplied as a sample, is not needed again, since it can be memorized and reused in perpetuity as occasion demands. Thus for any given customer, offering a sample destroys the market.

Exclusivity of information

If the *right to use* information could be sold independently of the communication of the information then this problem could be overcome. Where technological know-how is concerned, it is feasible to monitor use, and hence the right to use the information can be separated from the information itself. This is why the opportunity to patent know-how and sell it under licence is worthwhile. The use of

information in a decision is, however, much more difficult to monitor, since a decision often reflects the synthesis of many different kinds of information (see below) and is, in any case, a more introspective, and hence less public affair. Supplying information without the right to use it in decisions is therefore a quite impractical approach.

Another difficulty stems from the public-good nature of information. Because information can be memorized by the seller as well as the buyer, selling information shares it rather than transfers it (unlike the sale of an ordinary private good). Thus the buyer does not naturally obtain an exclusive right to the good. If he requires exclusivity then this must be separately enforced. Thus, once again, it is necessary to separate the right to use the information – which the seller of an exclusive right must surrender – from the information itself – which the seller still has – and, just as before, this is too difficult to do.

The typical buyer of transaction records and technological know-how is an entrepreneur. Entrepreneurs specialize in synthesizing information in order to take complex and risky decisions concerning innovation (Casson 1982). The private rewards of entrepreneurship stem from basing these decisions on better information than other people have. If all entrepreneurs had the same information then competition between them would dissipate the benefits of their activity entirely to their customers and suppliers.

Entrepreneurs are therefore very keen to buy exclusive rights of the kind described above. Because of the difficulty of legally enforcing the exclusivity of their purchase, entrepreneurs may prefer to buy information from people who they know are not in a position to make competing use of the information. Thus to reassure their entrepreneurial customers, many specialist suppliers of information publicly commit themselves not to diversify into their customers' activities.

The preceding argument shows that the market for information experiences a unique combination of difficulties, which make its transaction costs very high. In some cases the problem can be avoided by internalizing the market (Buckley and Casson 1976). The supplier may keep his information secret and integrate forward into its exploitation, or the user may integrate backwards to procure information from an internal source. In other cases private markets in information fail altogether. Either the state steps in to subsidize the production and dissemination of information, or the information simply does not get supplied at all.

Price information – should it have a price?

The fact that information is, to some extent, tradable raises a problem of regress which, if not handled carefully, can lead to an apparent circularity. For when rights to information are traded, information is needed to make these markets work. It is, however, price and quantity information in the form of offers and responses that is required. Thus the circularity is broken by recognizing that it is a different kind of information that is involved in making the market work.

But although it is information of a different kind, it may still be asked why this kind of information is not subject to the same sort of quality problems. The answer is that offers and responses are not sold, and hence there is no incentive to make up false offers and responses for sale. Moreover offers and responses may be accepted, in which case they are supposed to be implemented, and so it is only in special cases (such as trying to 'spoil the market' for a rival) that offers will be made that are not genuine. Thus price and quantity offers do not suffer from the same problems that transactions records and know-how do.

The issue is not yet fully resolved, however. For why are offers and responses not sold? Why should a dealer who is invited to make an offer for some second-hand goods not demand a fee to cover his time and trouble should his offer not be accepted? More to the point, why should someone who makes an unsolicited offer to someone else not be expected to offer them a fee to cover their time involved in making a response? The issue is a real one because dealers do indeed charge valuation fees when there is no prospect of the quotation leading to a sale. Moreover some mail-order companies offer payments to people who respond to their invitations (although the payment is usually contingent on the nature of the response).

The answer seems to be that, quite simply, the fees would be too small and too numerous to collect. The information costs involved in 'pricing' the individual efforts involved in two-way communication are simply too great.

Yet given that effort is costly, why do people continue to participate in dialogues from which they are unlikely to benefit, and for which they receive no payment? The explanation is that in most societies custom dictates an obligation to respond. The obligation is usually contingent on the nature of the enquiry. Unsolicited promotional literature does not merit even a polite refusal (the custom is to 'bin' it), whereas a general enquiry may qualify. A

request for a personal reference, on the other hand, normally carries a definite obligation to reply.

Such customs are very useful in sustaining two-way communication in the absence of finely tuned incentives. They avoid the problems caused by failure to confirm the receipt of an important message, to reply to an outstanding offer, or to answer an important question on which a crucial decision may depend. As shown below, customs have always functioned as a means of economizing on information costs.

THE INFORMATION-INTENSITY OF DIFFERENT MARKET TRANSACTIONS

It has been stressed above that a major function of business information is to support the market mechanism. An efficient market minimizes the transactions costs incurred in sustaining a given level of trade. Most transaction costs are incurred by middlemen, who provide specialized services that make trading more convenient for customers and suppliers.

If transaction costs are very high then organized markets cannot operate, since the middleman's average cost outweighs the margin he earns as his share of the gains from trade. As transaction costs fall, so markets proliferate, and as they do so each market tends to concentrate on a more specialized niche. The limits to this process are set by the fixed costs of organizing markets, and in particular of maintaining the network of contacts around the middleman's hub.

As product varieties proliferate, so consumers will be tempted to allocate a smaller proportion of their personal expenditure to each. This leads to a multiplicity of small transactions, which is limited by another fixed cost – namely the fixed cost of negotiating and enforcing a contract, independently of its value. The more intensive are the information costs of a given market, the sooner the limits to the proliferation of transactions become binding.

There are a number of factors which cause information costs to vary systematically across different markets. These cost differences will be reflected not just in the volume of trade, but in the way contracts are specified and the way the intermediaries carry out their operations (see Table 7.1). The level of information costs can therefore explain a good deal about the institutional structure of a market.

For some products, such as clothing and software, it is important for the individual requirements of the customer to be satisfied very closely. Now it is obvious that the less standardized and more

Table 7.1 Factors increasing the information-intensity of transactions

Factor	*Specific to*
MAINLY AFFECTING PROMOTIONAL ACTIVITY:	
Dimensions of quality: the number of relevant product characteristics, reflecting the multiplicity of performance characteristics which concern the customer	Product, customer
Customization potential: the premium that customers attach to a product that exactly meets their idiosyncratic needs, and the feasibility of achieving this without significant loss of economies of scale	Product, customer
Novelty of the product, and its complexity of use	Product
Product hazard: the danger of imperfections in the product, and the extent of natural quality variability; the problem is compounded if samples of the product are difficult to display and if delivered supplies are difficult to check by inspection	Product
Security of property rights: the complexity of property rights (as in house purchase) and the importance of assessing how easily they can be enforced (as with patents)	
Sophistication of the customer	Customer
Reputation of the middleman, and the general degree of trust in the society	Society
MAINLY AFFECTING THE MANAGEMENT OF TRANSACTIONS	
Payment methods	
Difficulty of effecting spot payment, owing to the use of common carriers for delivery or a significant component of 'after-sales' service	Location
Need for currency conversion, when exporting to certain countries (or importing from them)	Location
Need for customer finance, owing to the large value of the purchase relative to the customers' wealth	Customer
Pricing arrangements	
Price discrimination: importance of price-inelastic demand and scale of economies in production, together with the feasibility of preventing resale	Product
Reliance on negotiation rather than firm quoted prices	Product
Planning of supplies	
Provision for advance orders, reservations, etc., owing to the need to guarantee access to a good or service at a particular time	Product, customer

Table 7.1 Continued

Factor	*Specific to*
Secondary market available for trading transferable claims (orders, reservations, etc.) prior to their maturity	Product society
Sophisticated queuing and rationing rules used when orders are fulfilled spot at quoted prices; particularly important for perishable products for which inventory cannot be held (e.g. services)	Product, society
Mainly affecting distribution of the product	
Pre-arranged delivery to customer's premises: the administrative problem of timed consignment to a specified address is compounded by the large number of addresses associated with a diverse customer base, and is particularly common in consumer goods industries	Product, customer
The product is a collection of components which needs to be separately delivered and cannot be pre-packaged by the middleman	Product
The product is a claim to a sequence of timed deliveries, which may also be contingent on particular events. This is particularly common with financial assets and insurance policies	Product

customized the product, the larger is the amount of information the middleman needs to process. Thus there is a trade-off between customer satisfaction and transaction cost.

An analogous trade-off applies in the case of pricing. Producers operating under increasing returns to scale cannot break even by pricing at marginal cost, although it would pay them to expand output at this price if they could do so without reducing revenue elsewhere. The answer lies in price discrimination, but discrimination requires a great deal of information to calculate exactly what price each segment of the market will bear. Replacing a simple uniform pricing tariff with a complicated discriminatory one also raises communication costs, while policing the resale of products between customers, which is induced by discrimination, incurs monitoring costs as well. An extreme form of discrimination involves negotiating individually with each customer, which is very time-consuming for both parties involved. Because of the high fixed costs of information processing, discrimination is therefore usually worthwhile only where high-value transactions are concerned.

Some products need to be delivered to the customer's premises because they require specialized installation, whereas others can be

easily collected by the customer from the factory or shop. Collection clearly economizes on communication, because the supplier does not need to be told where the customer lives. (In some cases, though, the supplier may insist on delivering when it is not strictly necessary, as he can then enforce discrimination between customers on the basis of their location.)

The greater the diversity of the customer base, the greater are the information economies afforded by collection. Because consumers are more numerous than producers, collection is particularly suitable for consumer goods, quite apart from the fact that producer goods are more complicated than consumer goods and so more likely to need specialized installation anyway.

Information about a product is required for customer reassurance when there is a risk of a hidden defect which could have hazardous consequences. This is a special case of the general point that societies where people do not, in general, trust one another's competence or integrity have a much greater demand for information because people need to calculate exactly who is likely to default on a contract and who will be reliable.

The sophistication of the customer is an important influence on the amount of information that the middleman needs to convey. Customers begin with a problem to which they require a solution (Casson 1990, ch. 3). The more they know about the technical possibilities of solution, the better able they are to specify exactly what they want. The less they know, the greater the dialogue that is involved with the middleman in clarifying their wants. The need for dialogue is typically greatest for new products, which are therefore often sold to trend-setting customers by technically knowledgeable representatives with factory experience. As the product matures, customers find it easier to specify their needs, since they have witnessed the product in use by other people, and so promotion can be delegated to less knowledgeable people operating at the retail level. An important consequence of this is that cheap communication and consumer sophistication are both important in sustaining rapid innovation.

Communication becomes intense when sorting out problems. Consumer sophistication helps here as well, as sophisticated consumers are less likely to misuse the product – a particularly important consideration where complex durable goods are concerned. In some cases different components of the product are supplied directly by different people – for example, a package holiday tour operator relies on airlines, coach companies and independent hotels for many of

the services included in the package price. Under these conditions the allocation of responsibility for default, and the negotiation of compensation, can be extremely complicated.

Money is a major economizer on information (Goodhart 1975). It is homogeneous (apart from the risk of counterfeiting) and comes in standard denominations. As a specialized medium of exchange it decouples the two sides of a barter transaction and so allows trade to take place without a double coincidence of wants. It is even more advantageous where complex multilateral deals are involved, since these would be very information-intensive to set up and the gains from decomposing them into a sequence of bilateral monetary deals are thus particularly great.

Keeping track of debts is information-intensive too, even when only monetary debts are involved. Spot transactions therefore economize on information, compared with those where payment occurs before or after delivery of the product. When people trade regularly it is often economical to consolidate payments using monthly accounts. This reduces the frequency of payment; however, it requires investment in accounting records, and regular checks on the creditworthiness of account-holders.

Domestic retail transactions can be handled readily using cash, but international transactions (many of which are at the wholesale level) may require quite complicated credit instruments, creating a demand for banking services. The problems of discounting bills and clearing cheques are compounded by currency-conversion problems when trading between different currency areas.

If information costs were totally ignored then economic efficiency would be best achieved by setting prices in a continuous competitive auction. But participation in auctions is time-consuming, and so it is often cheaper to quote prices which are only periodically changed (Okun 1981). When quoted prices are sticky, temporary shortages or gluts can emerge, and under these conditions rules are needed for the allocation of priorities. It is here that, even in quite sophisticated economies, custom plays an important role.

The simplest custom is the queue – the principle of 'first come, first served' – although it is not usually the most efficient, since queuing is time-consuming because most queues require a personal presence to safeguard one's place. An alternative system is to confer priorities on certain people to enable them to get served first. These priorities can be purchased directly – for example, by paying a subscription to a privileged club – or indirectly, by competing to achieve a suitable social status. Privilege and status tend to be efficient (though unjust)

because the underprivileged recognize that they have little chance of being served and so do not waste their time in the queue.

The middlemen can reduce the incidence of queuing, and generally reduce the frequency of stock-outs, through holding large inventories. This implies a trade-off between information costs and inventory costs. A given level of service (percentage of spot orders satisfied on time) can be obtained either by holding a large inventory, or by holding a continuous auction instead of setting a sticky price.

An analogous trade-off prevails between information costs and precautionary money balances. Cash balances could be virtually eliminated if all goods were ordered and paid for in advance. Thus whether it is goods or cash that is involved, economizing on information means either poorer service, or larger inventories being held.

An important consequence of this analysis is that reductions in information costs should induce reductions in inventory levels relative to output, and reductions in cash balances relative to income. Historically, this should reveal itself in faster 'stock-turn' in wholesaling and retailing, and an increased velocity of circulation of high-powered money. The main qualification is that if greater wealth also leads to greater demand for convenience of service, stock-turn and velocity of circulation may decline more slowly than they otherwise would to allow the quality of service to rise. The predictions of faster stock-turn and higher velocity of circulation appear to be broadly consistent with historical evidence from advanced economies.

In the absence of information costs economic efficiency would also be served by trading claims for future delivery as well as for spot delivery. Customers would accommodate unforeseen changes of plan, not by deferring commitments to purchase, but by regular adjustments to their portfolios of outstanding claims. Claims would, in principle, pertain to every conceivable kind of good and service and every future date. In practice, though, even the most sophisticated contemporary economies operate secondary markets only for a few types of goods – namely money (financial markets) and commodities (mainly forward and future markets in metals and grain). People who wish to establish claims on other goods either place a long-term order with a supplier – which is normally a non-transferable claim – or hold financial assets which they plan to convert to goods later at whatever the spot price of the good happens to be at the time. Risks relating to the future money value of the financial asset can be minimized by holding an asset that matures at the intended date of conversion, or by hedging using other financial

instruments, such as options and swaps. Risks relating to the price of the good to be acquired can be controlled only by selecting a good whose price is relatively stable, and therefore easy to forecast on the basis of current prices. This is one of the instances where price data on recent transactions may be valuable to people who are not currently active in the market, and hence where records of business information may have commercial value.

Putting all these factors together, it is easy to see why so many goods are sold through retailers at uniform sticky prices in return for cash payment. This arrangement is ideal for small-value transactions, where the fixed component of information cost would otherwise become too high. As transactions increase in value, however, it becomes more worthwhile to invest in information. With a high-value transaction it is worth investing in negotiation in order to achieve a small proportional reduction in price through the exercise of bargaining power, or a marginal differentiation of the product to better satisfy individual wants.

As people become wealthier they will also be more concerned about taking delivery of products at a time and place convenient to themselves, and obtaining insurance that guarantees prompt response to subsequent maintenance problems. All of this increases the information component of the overall package they demand. These greater information costs may be partially offset, however, by customers' willingness to buy less frequently and in greater quantity. By dealing in greater bulk the number of transactions required to distribute a given quantity of product to a given customer in a given period can be significantly reduced. Trends towards greater convenience and greater bulk have been an important influence on retailing methods in advanced economies in the post-war period.

STANDARDIZATION

Scale economy, compatibility and substitutability

The preceding discussion highlights what a heterogeneous place the world can be. Transactors in different locations require specific wants to be satisfied at specific times under specific circumstances. Designing a customized solution to every problem, and negotiating a special price, would create enormous costs. It is therefore necessary to aggregate wants into different categories, and to provide a standard solution to each category at a uniform price, so as to spread the fixed costs of each solution over a large number of cases.

Such economies of standardization acquire a special significance, however, when establishing a network of communication. To begin with, communication is normally a two-way affair, and so each party functions as both the sender and the receiver of messages. The gain from standardizing them on the same communications protocol is not just that one protocol is cheaper to develop than two, but that two different protocols will prove incompatible. Compatibility is therefore an important attribute of standardization so far as communication is concerned.

Standardization also promotes interchangeability where pairwise communication is concerned. If all members of a group are standardized on the same protocol then it is easy to switch partners. Thus if circumstances change there is the flexibility to open up negotiations with another partner instead. If all partners are equally suitable it may still be advantageous to make contact with other partners to obtain additional quotations and improve bargaining power. Either way, economic efficiency is likely to be improved.

These gains from compatibility and substitutability are also manifest in the field of production – in particular where multi-component goods are concerned. The standardization of physical connections, such as plugs and sockets, ensures that components made by different people are physically compatible when they are assembled for use together. It also means that one component within an assembly may be substituted for another. A different component may be inserted to give a new variety of the finished product, or another unit of the same type may be inserted to replace a defective item (particularly important when maintaining a fleet of vehicles with only a small inventory of spare parts, for example). These physical economies also generate informational economies because a given range of final products can be produced and maintained in use by an inventory management system which recognizes only a small number of different parts.

Impact of standardization on information flow

It is fairly obvious that the standardization of information protocols tends to increase business information flow. This applies both to 'hardware' standards for the design of telecommunications sytems, for example, and to the 'software' standards created by a common language. Thus attempts by the International Telecommunications Union to establish international hardware standards, and the growing use of English as the international language of business, both promote international flows of business information.

It is interesting to note, however, that standardization in the fields of technology and product design tends to reduce information flow. Rapid convergence on best-practice technology means that there are fewer different technologies around, and hence less information is required to describe them all. Similarly the emergence of standardized mass-produced products reduces the need for intensive information flow to customize products. Fewer varieties not only economize on the fixed costs of production; it also economizes on the fixed costs of product specification as well.

These information savings are, however, largely offset by the fact that standardization has permitted faster innovation, and in particular more frequent incremental innovation, so that the product range, though small, changes more often. Thus while people may still need to know less at any one time, because fewer varieties are available, they may need to learn more intensively because their limited knowledge becomes more rapidly obsolete. This imperative for continuous learning to keep up to date is a major source of interest – and at times a major source of stress – in modern life.

BUSINESS INFORMATION IN ORGANIZATIONS

Two-stage allocation of resources

In a modern economy the way the division of labour is applied to business information is quite subtle. Many resources are allocated in a two-stage procedure, in which markets allocate resources between organizations, and organizations then allocate resources to specific issues. Thus the labour market allocates workers between firms, but firms allocate workers between tasks. Similarly the capital market re-allocates bundles of resources between firms through mergers, acquisitions, divestments, etc., leaving each firm to decide how each unit of resource is to be deployed. In both cases the information flow within the market complements the information flow within the firm.

The information used by the market reflects a higher level of aggregation in the description of resources than does the information used within the firm. Thus mergers and acquisitions are decided only on the basis of summary measures of performance pertaining to aggregates of resources. Information relating to specific issues remains locked in to the lower levels of management and it is transferred between the owners as part of the value of the firm as a going concern.

Organizations and their information flows

Organizations exist because individuals choose to delegate responsibility to them. Private firms obviously act on behalf of their owners but even state-run organizations may be considered as acting on behalf of the citizens. One of the advantages of delegating decisions to an organization is that the quality of the decision-making may be improved. Organizations can routinely channel relevant information to an experienced manager who is an expert in his or her field. This is another aspect of the division of labour in information handling noted above. Another advantage is that decisions within an organization can be coordinated rather differently from the way an ordinary market does it. Junior managers can be allocated responsibility for a particular subset of resources. They all report to a senior manager who then coordinates their individual plans. Such coordination can be based on either quantity or price.

This choice is crucial so far as the nature of business information within the firm is concerned. The senior manager may concentrate on reconciling subordinates' provisional quantity plans, calculating the material imbalances and adjusting the plans until equalities are achieved. Alternatively, the senior manager may set provisional internal prices to which subordinates respond. By instructing subordinates to maximize the profit imputed to the resources they are responsible for, the managerial system can mimic the operation of a market.

This internal market may well prove more effective than an external one because no change of ownership is actually involved and so the incentive to haggle and cheat is reduced. The main disadvantage of the internal market is that, since managerial rewards are only tenuously linked to imputed profit, managers may not bother to play their role properly.

The possibilities for using price and non-price coordination within markets and organizations are illustrated in Table 7.2. The empty cell in the top right-hand corner is explained by the fact that in a private-enterprise economy, planning without prices would be unacceptable outside of an organization unless people were in complete consensus about how resources should be utilized. Such consensus would reflect an improbably high degree of group-centred altruism within a private-enterprise system.

Budgeting

Because the typical firm operates in a market environment which sets prices both for labour and for the use of capital (through wages and

Table 7.2 Alternative coordination mechanisms available in markets and organizations

	Mechanism	
	Use of price as well as quantity	
Institution	*Yes*	*No*
Market	Conventional external market	
Organization	'Internal market'	Hierarchy based on quantity plans

Note: An external market involves a change in the ownership of the resources that are reallocated whereas an internal market does not.

interest rates respectively), it is possible for the hierarchical firm to adopt an intermediate approach to planning, based not upon price or quantity, but value. Subordinate managers in charge of specific operations are not allocated quantities of inputs but are allocated a budget with which these inputs can be procured. The output mix is still determined centrally, using quantity planning, but the selection of appropriate inputs is devolved using the budgetary system. Individual managers can procure resources internally (at shadow prices) or externally (at ordinary market prices), although the firm may require that priority is normally given to internal sources. This approach is particularly useful in enterprises producing non-marketed output (state-run health, education, law and order, etc.) from reasonably standardized inputs available at competitive prices. In such organizations, business information signifies mainly budgetary information, and the higher management function becomes the setting of budgets and the monitoring of over-spends.

FROM CUSTOM TO CONTRACT: THE INFLUENCE OF INFORMATION COSTS ON THE EVOLUTION OF ECONOMIC INSTITUTIONS

Falling information costs

This section argues that many aspects of economic history can be understood as the consequence of a process of economic liberalization driven by progressive reductions in information costs. Liberalization is seen principally as a transition from custom to contract, with the transition to and from centrally planned systems being a secondary issue (Hicks 1969). Reductions in information costs are attributed to significant technological advances, all of which are well known to historians of science:

the introduction of standard weights and measures, which eliminated local variations in the specification of quantity;
the use of clocks, and the standardization of local times that came with the spread of railways and telegraphs;
developments in cartography, which made long-distance postal communication easier to organize;
improvements in scientific classification, which standardized the grading of agricultural and mineral products;
improvements in wireless and telephony, which have led to virtually instantaneous satellite and cable communication; and
the development of computers, and associated software and peripherals, which facilitate the storage and interpretation of large amounts of information.

It is, of course, true that the initial impact of innovations in remote communications – for example, carriage of mail by railways, liner ships and aircraft – was mainly to improve the *quality* of information flow – as measured by speed, reliability, and the frequency of the intervals at which information can be sent – rather than to reduce the price. Quality of communication which was previously not available at any price was now available at an affordable price. Since the innovators of the new systems attempted to charge a quality premium, the affordable price would often be well above the lowest available price. The original system – the mail coach and the courier, for example – often continued in operation, utilizing at least some of its capacity until lack of investment in replacement caused its decay. In other cases the original system did not become obsolete, but simply concentrated on a smaller market geared to a different clientele. In all these cases, costs of communication only fell, at least in the short run, on a quality-adjusted basis.

Direct measures of the fall in information costs are difficult to obtain. It is unreasonable to argue that the growth of business information generally is entirely a consequence of falling information costs, since the demand for information is likely to be income-elastic, and hence to have increased as a result of rising prosperity. The most plausible scenario is illustrated in Figure 7.1. This shows the interaction between the demand and supply of business information, conditional upon a constant quality of communication. The horizontal supply curve of information S_0S_0' shifts down to S_1S_1' on account of technical progress in communications, while the demand curve D_0D_0' shifts to the right to D_1D_1' on account of rising real incomes. As a result, the equilibrium shifts, in the long run, from E_0 to E_1, passing

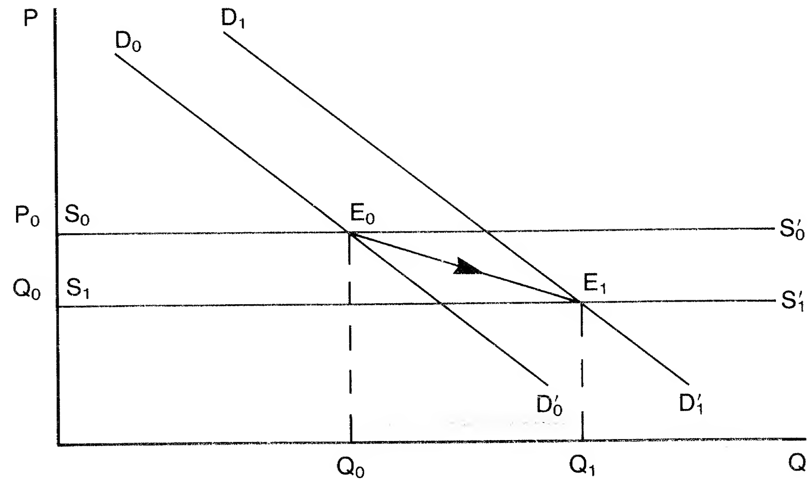

Figure 7.1 Changes in the price and quantity of business information
Note: The initial price and quantity are P_0,Q_0 respectively. The final price and quantity are P_1,Q_1 respectively.

on the cost savings in full to consumers through a lower price, and supporting a significant increase in the quantity of information flow.

How customs economize on information costs

The cornerstone of the argument is that custom is an economically rational response to high information costs, and hence can be analysed as an economic as well as a social phenomenon. In particular, it is a response to prohibitive costs of negotiating and enforcing a wide range of different individual agreements. Although customs are typically justified within a society by appeal to revelation, tradition and group loyalty, this should not distract attention from the basic rationality of the rules they invoke.

A simple society facing a scarcity constraint encounters a number of strategic issues. These include how to organize team production, how to benefit from specialization, how to care for the old and the young, and how to insure against individual misfortune and disaster.

Consider team activity first. When it is too costly to tailor contracts individually to each team activity, the obvious alternative is to establish a standard contractual form. With no contract at all, conflict over distribution of the product may lead to the product itself being spoilt; which is clearly inefficient; or, if the product is simply appropriated by the strongest, most alert and tactically sophisticated individual, then the injustice of this may undermine the social cohesion essential to the activity of the group. The absence of a specially negotiated contract must not, therefore, lead to a default position in which no contract prevails. To avoid Hobbesian anarchy in the distribution of the product, the standard contract is presumed to always apply by default. Moreover the moral arguments advanced in favour of the terms laid down by the standard contract may suggest that any attempt to deviate from the standard contract is immoral. In this way the standard contract acquires the force of a custom to which everyone must conform.

The custom must address the problem that team output may be uncertain at the time that members commit their effort – particularly in societies where the technological ability to control the natural environment is relatively low. This probably accounts for the predominance of simple sharing rules – such as share-cropping in the agricultural sector of less-developed countries.

The sharing rule has three advantages over individually tailored contracts in a simple society. Two arise because it is a standard that is uniformly applied by default, and the third because it affords a simple form of insurance.

As a standard, it avoids the costs of individual negotiation, noted above, which may be prohibitively high when communication is slow and literacy is poor. Second, in a society with limited trust a standard is easier to enforce than an individual contract. This is particularly true where no written and authenticated record of a contract exists, for then the only independent evidence is provided by witnesses, who may themselves be intimidated or corrupted by a potential cheat. Without reputable, impartial witnesses a cheat can always claim that the contract was different from what it was. But with a standard contract, everyone can see whether its terms have been breached or not.

The final point is that the share contract spreads risk fairly evenly. In more sophisticated societies the risks of team production are concentrated on particular roles – such as the owner of the team, who has a special incentive to check shirking (Alchian and Demsetz 1972). But for this to work properly it is often necessary for the owner's

risks to be shared out again, so that in a large enterprise too much risk does not fall on a single person. This requires a venture capital market, and preferably a secondary equity market as well, to afford risk-bearers greater liquidity. When information costs make an equity market too expensive to operate, specialization of risk may be inferior to spreading it over the team membership as a whole.

In certain cases team production may require a synthesis of special skills. Custom may therefore dictate the identification of certain roles within the team – roles that would be formally defined as bureaucratic offices within a highly literate society, but which in a simple society may be identified simply by titles, badges, seals and rights to deference (Weber 1947). But this in turn raises the question of who is to be assigned to such roles, and how succession is to be organized when someone retires or dies in office.

Constitutional rules typically cover these issues. When a labour market with individually negotiated appointments is too difficult to operate, standard rules that assign people to roles by their non-manipulable characteristics such as gender, family pedigree, etc., avoid conflict over preferment to the best positions.

In a sophisticated society problems of old age can be addressed using personal pension plans. But in a simple low-trust society no one could have any confidence that pension-fund managers would either have access to assets (other than land) in which the premiums could be invested, or would not default by consuming the premiums as they were paid in. A simple rule that children inherit their parents' land and must, in return, care for their aged parents is much easier to enforce, although it does not, of course, cover landless and childless adults. Subject to these limitations, it combines a simple injunction to care for the elderly with an equally simple assignment of responsibility for this task.

Similarly, in sophisticated societies many of the costs of child-rearing are borne not by the parents but by the state, through free health care and education, tax allowances and so on. Where the state either does not exist, or cannot be trusted, it is rational to adopt a custom that child-rearing is the primary responsibility of the parents, with this investment subsequently being repaid in kind by the grown-up children, as indicated above. (In some cases parents may delegate this responsibility to the extended family, such as grandparents, in return for subsistence support.) In this way custom avoids the negotiation of individual consumption loans which are paid back over the life cycle.

The main disadvantage of custom is, of course, its inflexibility. It

standardizes the treatment of very varied situations. It also makes the treatment of these situations difficult to change. Custom is difficult to change on the individual initiative of an ordinary member of a social group because such change would appear as deviance. Custom can only be changed quickly at the centre, by the leadership of the group, and it may take some time for information to filter up to this level. The popularity of the leader is also important; custom is difficult to change without general consent. If changes in the group's environment are essentially transitory then this inertia may actually be an advantage, since the smoothing-out of group responses permits further economies in information costs. But if the changes are permanent then the sluggish response may put the very survival of the group at risk.

As information costs fall due to increased literacy and improved scientific technique, therefore, custom tends to be replaced by negotiated agreement. Moreover, to achieve greater flexibility, contracts are renegotiated with increasing frequency. The contractual sector typically develops side-by-side with the customary sector, gradually increasing its share of economic activity as new industries, exempt from tradition, grow and custom-bound mature industries go into decline. Custom may, however, renew itself to some extent, as new industries begin to acquire their own traditions as they themselves mature.

How personal reputation replaces collective conformity in a contractual economy

It is, however, difficult for contractual trade to get started at all if there is a presumption that those who deviate from custom cannot be trusted. Trust can be engineered in two main ways (Casson 1991): by a moral commitment not to cheat; and by a system of material penalties applied to cheats by a monitoring agency. The most obvious example of the latter is a fine administered by the legal system.

Monitoring is information-intensive, and so is difficult to organize formally in a simple society. But as information costs fall, monitoring becomes easier, and so less reliance needs to be placed on morality. A superior can trust subordinates simply because they know that it is now easy for him to measure their performance. Thus while the customary sector continues to rely mainly on morality, the contractual sector tends to rely more on monitoring instead.

But how can those in the customary sector tolerate arrangements in the contractual sector that violate their moral norms? One way is

for the political leadership to authorize these violations in return for taxes which can be spent to 'buy off' opposition (for example, licensing the private exploitation of a state monopoly in order to increase poor relief). Another strategy is to confine the contractual sector to foreigners (as when medieval sovereigns took 'usurious' war-loans from foreign bankers resident in their city).

A more radical approach is to replace the old morality with a new morality that is more conducive to contractual activity (Robertson 1934). Toleration of diversity can be elevated into a virtue. Middlemen in the contractual sector can gain a reputation for integrity on the basis of their non-conformist religious convictions. Their practical ethics of giving good measure, charging fair prices and not adulterating their products, gives added credibility to these convictions. As a result, they build a reputation that distinguishes them from those who break with custom simply out of bad faith.

Reputation effects can be strengthened when reputable individuals form themselves into an elite self-regulating group. This allows them to discipline each other for default by expulsion from the group. This reassures ordinary people that middlemen face more serious penalties than simply the loss of their own repeat business should they default. Since each honest intermediary's personal reputation is enhanced by his or her group affiliation, he or she has an incentive to participate in the sanctions applied by the group.

Reputation therefore becomes a most important element of business information in a sophisticated market system. Some reputations adhere to the individual and some to the group. Some are widespread and others localized. Many of the most valuable reputations nowadays are impersonal, and relate to organizations, and even to product brands.

The management of reputation through advertising, public relations and the manipulation of the media has become a major industry. One of the unfortunate consequences of this is that many reputations are probably unreliable. While the fall in information costs has led to a proliferation of reputational claims, there is a danger that, as with the sale of information, the proliferation of bogus information may create a cynical response. This could undermine quite valid reputations, and reduce the efficiency of markets as a result.

Custom based information economics today

As technological progress reduces information costs, the distance-related component of these costs falls faster than the other components. Thus the cost of sending a letter by courier depends mainly

on the distance involved, whereas the main cost of a telephone call is the time spent on conversation, which is independent of the distance involved. Thus as businesses have switched from couriers to post, and then to telecommunications, distance has become much less of an obstacle to communication.

A similar effect is discernible in freight transportation, where the terminal costs of packing and loading have fallen less than distance-related costs of vehicle movement (in spite of recent increases in the price of energy). Thus long-distance trade has become cheaper relative to short-distance trade, and the falling relative cost of long-distance communication noted above has reinforced this incentive to trade further afield.

As long-distance trade has increased, so custom has become even less help as a coordinating mechanism. This is because custom is no longer standardized over the market area. Local customs begin to appear as a negative factor leading to misunderstandings, which compound those originating from language differences. This further reduces the utility of custom in sustaining trade. Moreover, the increase in remote communication weakens the power of custom, since many of its sanctions relate to a face-to-face society in which social ostracism plays an important role.

More precisely, it is traditional customs that appear as the source of the problem. Customs are still required, but the relevant customs are those that support the efficient conduct of international trade. Because opportunities for face-to-face contact are rather limited in long-distance trade, the important customs are the conventions for the sequencing and formatting of remote communication. They govern the establishment of contacts (including the obligation to answer correspondence, noted earlier), the allocation of responsibility for making the initial offer, the specification of normal discount schemes and credit terms, and the procedures for invoicing and payment, whether cash on delivery, or on account.

There is, however, a question as to whether the moral obligation to respect these customs is as secure in a contractually driven society as in a more traditional one. Economic and social integration effected by international trade and communication encourages a relativistic view of local cultures. Local cultures often relate custom to powerful myths about the origins of the group. It is pertinent to ask whether, when these myths have been discredited, there is anything as effective as a local custom to put in their place.

It could be argued that formal legal systems, and their associated monitoring apparatus are an adequate replacement for traditional

customs, particularly when information costs are very low. But legal systems usually just codify conventions without necessarily legitimating them. It is, of course, possible to elevate respect for the law itself into a moral absolute, qualified perhaps by the need for democratic appointment of the legislative body. But it may be doubted whether such a moral system, divorced from myth and tradition, can by itself sustain even the limited set of customs necessary to sustain a highly integrated contractual economy.

LOOKING AHEAD: A CASE STUDY

The potential limitations of contract relative to custom are not only moral (as noted above) but technical too. This section examines a futuristic scenario in which the contractual approach is extended to cover personal transport by car. Certain aspects of this approach are already apparent in the use of car-parking fees and toll roads, but it is nevertheless interesting to contemplate how far a more systematic approach could go. This case study is particularly instructive because some rival modes of transport have already exploited contracts to a much greater extent than roads, and so the analysis also has a practical function in explaining why this is so.

A principle common to all traffic management is to organize vehicles (and pedestrians too, for that matter) into lines which move steadily in non-conflicting directions through a pre-planned network of channels. It is a substantial information economy to allow anyone access to the network without prior authorization and to avoid the need to track their movement. This can only be achieved however, by setting clear priorities at intersections where conflicting movements may occur. The simplest priorities are those based on direction of movement, which may be expressed absolutely (those entering the intersection from a minor road give way to those on the major road) or relatively (give way to the right). Head-on conflicts are avoided by simple injunctions to drive on one side of the road – a convention which also saves labelling each side of the road with the authorized direction of travel.

The basic principle of the moving line of traffic is similar to the principles of all physical flows – namely that adjacent elements move in the same direction at a similar speed. It is also akin to the queue of customers standing in line at the service desk – conflicting movements are avoided if everyone approaches the desk in sequence from the same direction.

Customary methods of traffic management have their limitations,

however. Unregulated access means that unnecessary queues develop, and the absence of tracking means that users cannot be readily advised of suitable diversions. Delays are caused by slow-moving vehicles, such as tractors and heavy lorries, which get mixed up with faster moving traffic, and urgent ambulance trips cannot always get the priority they require. If more information were used, more efficient utilization of available road space could be attained.

One approach would be for roads to emulate railways, which are much more information-intensive in their traffic management – a factor of some historical significance for the development of business-information systems (Chandler 1977). Suppose, therefore, that all the roads were managed by a traffic authority which regulated access to the network it controlled. All journeys would be individually priced. Roads would be divided up into lanes, as at present, and lanes would be subdivided into segments, each segment allowing a car to travel at normal speed and remain a safe braking distance from cars in the segments ahead of it and behind it in the same lane. Block signalling would be used, as on the railways, with traffic lights controlling access to each segment. A green light would signify that the segment ahead is free and a red light that it is occupied.

Each segment would have a user price for a given time on a given day, and this price would be used to ration demand. Before setting off on his journey (i.e. entering the network) each driver would call the traffic authority from his car (or home phone) to book a drive-path to his destination. A drive-path is a set of reserved segments which support a continuous journey. (If the driver cannot leave the network at his destination then he will have to book a round trip which includes a parking place at his destination.) The traffic-authority computer identifies a selection of possible drive-paths and invites the driver to select one on the basis of price, time of arrival, and perhaps the scenic quality of the route. The driver makes his choice, his bank account is debited, and his booking confirmed. A timed authority to enter the network is given. The route plan is then transmitted to the car's computer, which displays forthcoming manoeuvres as the journey proceeds. Magnetic loops in the road recognize the car's registration number and check for deviations from the authorized speed and route.

All sorts of problems are solved by this system. By giving the driver a personal identification number (PIN), thieves will be disabled from getting authority to drive the car away, since they cannot match the PIN to the registration number built into the car's computer. Unforeseen delays due to traffic congestion are eliminated as the traffic

authority's computer devises routes around the bottlenecks. Queues at road junctions are eliminated as the computer-controlled lights know just how much traffic is expected at what time for each intersection and what kind of manoeuvres have to be made. Provided people obey the traffic signals, and there are no programming errors, accidents caused by personal misjudgement cannot occur.

Although this market-based system is designed to provide flexibility, the monopoly power invested in a state traffic authority could lead to inertia so far as improvements to the network are concerned. To provide more incentive for investment and innovation it is possible, in principle, to privatize the operation and, indeed, to specialize particular functions on different kinds of firm. Roads could be owned by, say, a trunk-road owner and a set of regional firms operating feeder roads. New entry would be encouraged by simplifying land-use planning procedures. Retail firms could make block purchases of user rights to various segments, and sell drive-paths over these segments in competition with each other. Smaller groups of rights could be traded between the retail firms to accommodate variations in their market shares on particular routes. These retailers would function much as package-holiday companies do today, putting together an itinerary by combining different inputs acquired from independent suppliers.

There are, of course, many practical difficulties with implementing a futuristic scheme of this kind. It is worth noting, however, that on careful examination many potential problems – connected, for example, with accidents and the provision of emergency services – can be dealt with better than at present with only minor modifications to the procedures outlined above.

It should also be noted that most of the constituent elements described above are already in place, either in the field of rail and air transport, or in ordinary retailing. What is novel is the combination of these elements and, above all, the sheer dimension of the scheduling calculations: millions of vehicles traversing millions of small segments on a network that offers billions of permutations of routes. The most important technical limitation is probably whether sufficient computing power can be provided to supply as speedy a response to incoming requirements as the customers will require.

The overriding objections, though, are probably economic and social ones. Would the benefits be sufficiently great to cover the set-up costs involved, and would the electorate tolerate the tracking of individual movements involved in a system of this kind? Probably they would not in the West, but in the growing congested city states

of Asia, where there is a longer tradition of state innovation, and fewer roads to map out, the future of road transport may not be too dissimilar to the picture sketched out here. The progress from custom to contract, outlined in earlier sections, may therefore continue, bringing new areas, still regulated by custom, into the contractual sector. There will be social resistance to this movement – as there always has been – but with one significant difference. Whereas the extension of contracts has, in the past, been associated with greater liberalization, the intensive-information requirements of future extensions may be seen as compromising established freedoms instead.

CONCLUSIONS

This chapter has examined a range of related issues concerning the economic role of business information. It has been shown that the information used for economic coordination may consist of either prices, quantities or values, or combinations of these. Ordinary markets rely on price information provided by middlemen, backed by quantity responses from their customers. Organizations can choose between a wider variety of methods. One method mimics the market, another employs budgets, whilst a third relies on the reconciliation of detailed quantity plans.

It has also been shown that as the coordination process proceeds, the nature of the information changes. In a market context, it changes from offers to rights and obligations (after agreement between the parties) to historical record (after completion of the transfer of resources).

An important distinction has been drawn between information that is sold and information that is not. The sale of information induces quality problems because it encourages the supply of bogus information, and this problem can become so severe that the sale of good information is wiped out.

If information is allowed to go unpriced then incentive problems of a different kind arise. People do not have sufficient inducement to participate in communication from which other people will benefit. Customs relating to the conduct of correspondence and conversation, backed by an ethos of 'good manners', overcome these problems. Such customs also help to achieve compatibility of interpretation, and effective social networking, within the social group.

Changes in the cost of business information appear to be of great historical significance. The transition from custom-based to

contract-based societies can be understood in these terms. Contract-based societies exploit the opportunity to proliferate markets that is created when falling information costs reduce the fixed costs of market intermediation. The proliferation of markets would have gone even further if it had not been for the increasing standardization of product design. This has been encouraged by new technological opportunities to exploit manufacturing economies of scale, and by the importance of network externalities in the utilization of modern communication systems.

As markets have proliferated, so traditional customs have gone into decline. The most important customs now relate to the negotiation of contracts and, more generally, to the establishment of connections through networks. Because markets now span great distances, these customs mainly concern remote communication and not, as with traditional customs, communication face to face.

Because traditional customs were very localized, and often idiosyncratic, they are now seen as an obstacle to progress. These customs were, however, typically linked to powerful myths, which gave conformity with custom considerable moral force. Modern customs have a much more utilitarian justification, and it remains to be seen whether they will elicit the degree of voluntary compliance that is necessary for effective coordination. If they do not, then society may survive only by recourse to a more coercive use of information – namely the intrusive monitoring of behaviour to achieve conformity purely through legal sanctions. It is these social issues that are likely to prove decisive in the way the new information technologies are applied in the business-information field, although technological opportunities will continue to play an important role.

NOTE

1 I am grateful to Lisa Bud-Frierman and Derek Purdy for comments on an earlier version of this paper, and to the participants at the conference on 'Global Perspectives on Business Information' held at the University of Reading, April 1992, for their remarks.

BIBLIOGRAPHY

Akerlof, G. A. (1970) 'The market for lemons: quality uncertainty and the market mechanism', *Quarterly Journal of Economics* 84: 488–500.

Alchian, A. A. and Demsetz, H. (1972) 'Production, information costs and economic organization', *American Economic Review* 62: 777–95.

Arrow, K. J. and Hahn, F. H. (1971) *General Competitive Analysis*, Edinburgh: Oliver & Boyd.
Babbage, C. (1832) *On the Economy of Machinery and Manufactures*, London: Charles Knight.
Binmore, K. and Dasgupta, P. (eds) (1986) *Economic Organizations as Games*, Oxford: Blackwell.
Buckley, P. J. and Casson, M. C. (1976) *The Future of the Multinational Enterprise*, London: Macmillan.
Casson, M. C. (1982) *The Entrepreneur: An Economic Theory*, Oxford: Martin Robertson; repr. Farnborough: Gregg Revivals, 1991.
—— (1990) *Enterprise and Competitiveness: A Systems View of International Business*, Oxford: Clarendon Press.
—— (1991) *Economics of Business Culture: Game Theory, Transaction Costs and Economic Performance*, Oxford: Clarendon Press.
Chandler, A. D. Jr (1977) *The Visible Hand: The Managerial Revolution in American Business*, Cambridge, MA: Belknap Press of Harvard University Press.
Coase, R. H. (1937) 'The nature of the firm', *Economica* (New Series) 4: 386–405.
Fama, E. F., Fisher, L., Jensen, M. and Roll, R. (1969) 'The adjustment of stock prices to new information', *International Economic Review* 10: 1–21.
Goodhart, C. A. E. (1975) *Money, Information and Uncertainty*, London: Macmillan.
von Hayek, F. A. (1937) 'Economics and knowledge', *Economica* (New Series) 4: 33–54.
Hicks, J. R. (1969) *A Theory of Economic History*, Oxford: Clarendon Press.
Okun, A. M. (1981) *Price and Quantities*, Oxford: Blackwell.
Robertson, H. M. (1934) *The Rise of Economic Individualism*, Cambridge: Cambridge University Press.
Spence, A. M. (1974) *Market Signalling: Information Transfer in Hiring and Related Screening Processes*, Cambridge, MA: Harvard University Press.
Weber, M. (1947) *The Theory of Social and Economic Organization*, trans. A. M. Henderson and T. Parsons, ed. T. Parsons, New York: Oxford University Press.

160 - 06

8 Official statistics and business

History, classifications, uses[1]

Alain Desrosières

N ϕ1

'Business information' is a peculiar concept for the economist: for a long time, economic theory dealt neither with business nor information. The firm was viewed only as a place for exchanging inputs and outputs; it had no substance. Information about the quality and the price of goods was supposed to be complete and perfect. Things began to change, on the business side, when the interest in the specificity of labour market and wage contracts (Coase 1937; Simon 1951), and more generally in transaction costs and in the relative efficiency of organization versus market started to grow. On the information side, Akerlof (1970) showed how the whole construction of general equilibrium had to be renewed if the consumer uses the *price* of a good as information about its *quality*: this case is not rare. Stiglitz (1985) initiated a vast research programme about the consequences of bounded information and uncertainties on the behaviour of a rational agent. These two new directions in economic theory, about business and about information, were linked: it was because the firm and its organization could be more efficient than the market for collecting and disseminating information and in preventing uncertainties and risks, that both lines of research were strongly connected. These approaches have been especially fruitful in the past twenty years.

This widening of the theoretical structure of economics was favoured by the fact that, in the 1970s, the labour market appeared to be particularly unworkable in the classical framework (Doeringer and Piore 1971). Studies about the 'internal market' opened the door to research about firms and the various dimensions of their organization and practices. As a matter of fact, business departments of some American universities, with Harvard in the vanguard, had, since the 1920s, developed 'case studies', from a management-training viewpoint. But this activity generally remained independent of economics

departments. Schumpeter was one of the first to make a connection between these perspectives. After him, historians took over and created a new branch in their discipline: 'business history'. The most influential among them was Chandler (1977): his *The Visible Hand* (in direct opposition to the 'invisible hand' of the market) described the construction of the big American firm in the nineteenth century (for a good survey of this literature, see also Mayr and Post 1981). The organization, as an alternative solution to market, was at the origin of debates dominated by economists like Williamson (1985).

A main point in the research of Chandler and others were the obvious benefits of standardization and mass production. This was connected with new techniques of accounting, of quality control and later, of statistical analysis. Interchangeability of parts played an important role in mechanical industries, from technical as well as economic points of view. The codification of the various dimensions of industrial activities was a necessary precondition for their statistical analysis. There was an operational and cognitive consistency between the developments of big business, mass production and standardization, and of the objectification and quantification of the knowledge produced by these new techniques. In fact, accounting or quality control preceded the statistics in its modern meaning, for two reasons. Statistics (as the etymology of the word shows it: a description of the state) was principally a government activity, and mathematical tools for statistical inference did not exist. But business statistics have a long history, as a government practice of the description of economic activities, largely independent of the mainstream of economic thought, at least until the 1940s.

We shall suggest here why the marriage between economic theory and empirical knowledge, based on statistics, took so long to occur. Then we shall select as examples of this difficult connection, different moments in the history of three branches of government business statistics: production and machinery, employment and wages, accounting and national income estimates. In this way, we shall attempt to show how the idea of 'information' (or 'knowledge'), as used by economists, is a strange object, without any cognitive specificities (as a peculiar language for objectifying the social world), or economic dimension (as in 'investment of form', implying a *cost* of design and construction, for a future *benefit* (Thévenot 1984).

STATISTICS AND ECONOMICS: A RECENT MARRIAGE

The use of quantitative data in economics is now so common that it is hard to imagine how recent it is and how rare it was until the

beginning of this century. The main economists of the nineteenth century were often suspicious about statistics and did not use them. This opposition is sometimes ascribed to the resistance of literary economists against the mathematization of their discipline, but this is a confusion. Those, like Walras, who succeeded in this formalization, were reluctant to use statistics. Conversely, taking statistics into account was normal for those who wanted to criticize 'abstract economics', in the name of history and observation of actual societies, as did the economists of the 'German historical school'. In this perspective, a descriptive and inductive method, including history and statistics, was opposed to an abstract and deductive method, implying mathematics, to give a general form to equilibrium theory. Some of the German historicists were good statisticians, as was Ernst Engel, director of the Statistical Office of Prussia, who organized a census of German manufacturers. On the contrary, Walras, Marshall or the Austrian economists, did not ask for such data.

Directly influenced by German historicists, American institutionalists of the early twentieth century, had the same resistance to abstract economics, and a similar interest in empirical and quantitative description. The most famous was Wesley Mitchell, who extensively researched economic cycles. American institutionalists played an important role in the development of a public statistical system in the 1930s (Duncan and Shelton 1978; Anderson 1988). The first econometric studies about cycles and supply and demand laws (Morgan 1990) were an important achievement of the period 1910 to 1940. They were conducted by Moore, an economist, somewhat hostile to deductive methods and influenced by institutionalists (Mitchell). It was only in the 1940s, with the introduction of probabilistic schemes and with the tension between data and theoretical models, that econometrics began in its modern meaning, with Frisch and Haavelmo (Mirowski 1989). But the old battle was not finished, and in 1949 Koopmans, a tenor of the new econometrics, and Vining, a student of Mitchell (Vining and Koopmans 1949), engaged in a rich controversy about the relative importance of measurement and theory.

The novelty of this debate lay in the fact that both sides were convinced of the usefulness of empirical data to prove their ideas. One contributory factor to this change was the 'nationalization' of statistics during the 1930s, in the United States, and the new responsibility of government for managing a macroeconomic policy. Public concern about economic policy had existed before, but the

nature of that concern was now different. This changed conception of government's economic function affected perceptions about the role of business information. For example, in the 1920s Hoover, as Republican Secretary of Commerce, encouraged an important but *local* information system about firms, employment, and the current economic context. He believed that the health of local business was mainly the problem of local businessmen, and that solutions to a potential crisis would have to come from their own initiative, supported by their knowledge of the particular situation. The only role of government was to help them to get this information, and there was no real need for a national totalization, although data about firms was important. Hoover, who became president in 1929, and remained in office until 1933, was faced with the big crash and depression soon after taking up his position; he could not find any solutions with this kind of policy.

With Roosevelt's New Deal, the need for national figures, especially about unemployment, became obvious, since the big decisions were now macroeconomic and national. Rate of unemployment, price index, national income, budget gap, federal debt, were all national measures. In this way, the firm by itself, as a complex organization, disappeared again for the benefit of national information. There is an ironic parallel between the ignorance of the firm in microeconomic theory, and the same ignorance in macroeconomic policies and the information system consistent with them. The causes of this ignorance are very different and do not have the same implications, but there is something common between them. The need of a simplified model, whether for cognitive or for political reasons, is incompatible with an adequate description of the complex and multifaceted firm. Simplification conceals this multiplicity of dimensions, an understanding of which is important for the formulation and management of policies. The economy of thought inherent in economic thinking constitutes simultaneously its strength and its weakness. The construction of statistics about firms, for example, can be at the origin of the same reductionism. But, as there are several means of access to business statistical information, it is possible to go further.

PRODUCTION: THE GOODS OR THE FIRMS

Statisticians describing industry had noticed, earlier than others, the depth and complexity of the firm. There is not a simple correspondance between one good, one market and one type of firm using a single technique. Statistical information about production may be

grouped and used according to very different criteria, and attention may be turned either towards the product or towards the firm. This tension was manifest in the history of French production statistics for two hundred years.

This distinction between different possible kinds of business descriptions is apparent in the classical opposition between monographs and statistics. Empirical sociology has a long tradition of discussion about this problem. A monograph is based on a typical case, a kind of average individual or household (Le Play), taken from a large population (Desrosières 1991a). But production analysis raises other questions, because there may be only a few firms producing one good. Firms may have very different sizes (that's why sampling methods are more difficult to use for firms than for individuals or households). The assumption of equivalence and comparability by statistical aggregation may appear as strange conventions. Thus, beyond this peculiarity of economic statistics, as opposed to social ones, we always find the same question: what is the status of the firm in the analysis? Is it reducible to an anonymous point in a market theory or in a statistical aggregation? Or has it something specific, needing *ad hoc* descriptions? Both answers are possible and are historically observed. The first one is given when government has some reason to set up global economic policies, for example protection or free trade; for a long time, this issue was at the core of statistical questions. The second answer appears during periods of rapid growth. Some firms are then taken as examples, and are described in great detail (especially their technological innovations and machinery). Innovation is an interesting case, because, by definition, it comes from *one* firm, this firm being different from all others, and the construction of the equivalence required by aggregation is especially questionable.

Even when this aggregation is done, the convention of equivalence is not obvious, as is shown by the history of industrial nomenclatures (Guibert, Laganier and Volle 1971). Production surveys have been organized in France several times since the eighteenth century. But criteria used for classifying activities changed completely from one survey to the next, reflecting different cognitive and political interests. In a nomenclature created in 1788, and inspired by physiocratic theories, industry was divided into three main headings based on the origin of raw materials: animal, vegetable, mineral. In this taxonomy, textiles were divided as follows: cotton, hemp and flax with 'vegetables' and wool and silk with 'animals'. Manufactured goods, like carpets, were classified as wool, and thus belonged to the 'animal' category.

In a survey conducted in 1841, at the beginning of rapid industrial growth, interest focused on new kinds of manufactures and machines, described in a monographic way, with great detail. In this research, data on innovation and performance are more interesting than averages and aggregations. Quantitative historians looking for data sources for their long chronicles are disappointed by the 1841 survey, because equivalences are absent. But historians of sciences and techniques appreciate it, because it gives examples of dissemination and uses of industrial innovations.

The context of the following census of industry, which took place in 1861, was completely different. A Franco-British free-trade agreement had just been concluded by Napoleon III, and, for the first time, French manufacturers were directly in competition with the foremost industrial nation. Government wanted to observe the consequences of the opening of this frontier. Hence, the main criterion was the end-product, as exchanged on the international market. The base for the equivalence convention was no longer the origin of the raw materials, but on the contrary, the destination or the final use of the good. There is a consistency between free trade and markets defined from demand side, and the role played by the end-product in the survey. From that perspective, the firm and its complexity and specificities had vanished again. Was the market in contradiction with firm uniqueness?

The Second Empire free-trade policy did not last long. It was abolished after 1871 by the Third Republic, which focused its policy on a 'middle class' of small firms (peasants, craftsmen, shopkeepers) and thus adopted a protectionist attitude. Businessmen were very suspicious about government interventions (except for tariffs) and about such direct industrial surveys as those of 1841 and 1861. In 1896, an indirect census of economic activities took place by asking active people, *in the population census*, about their occupation, and the activity and address of the establishment where they worked. Thanks to new mechanographical machines (including American Hollerith technology), it was possible to tabulate this large amount of data, and to produce figures distributing local establishments (but not firms as juridical and financial units) according to economic activities, and giving some information about employed people (men and women; 'chiefs', manual workers and non-manual workers). But these statistics did not convey any information about production itself, neither in volume nor in value. It was tabulated, every five years after the population census, until the Second World War.

During this period, the criterion for classifying activities was

somewhat different from the previous ones, which had been based on raw materials and final products. As the only information about firms concerned occupations, and not production or consumption, it was possible to compare establishments according to *techniques of production*. Here lies a third criterion, which is different from the others, and which is almost an *association criterion*: it is an attempt to build aggregates, through the grouping of activities frequently gathered together *in the same firm*. It could be a pragmatic way of solving the problems linked to the coexistence of different products in the same firm. This technical problem became quite important in France, because of the restrictions which took place during the Second World War and which influenced the economic organization; the idiosyncratic distinction between 'branch' and 'sector' results partly from the circumstances of the German-occupation period.

Business statistical information changed completely at this time, because of shortages resulting from German requisitions of French production. A dirigiste economy was organized by government, and it was in charge of allocating scarce resources on the basis of the amounts produced in 1938. Industrial surveys, about production and consumption of raw materials were needed to administer this programme (Volle 1982). This system of 'branches' surveys gave an important role to professional unions (*syndicats professionnels*), which had to group firms according to the goods they produced through collecting and aggregating questionnaires. These unions thus obtained great political and social influence. They still play an important part in 'branches' surveys, although the French administration attempted to recover a direct responsibility for them.

This particular history explains why French statisticians have a peculiar vocabulary, difficult to translate into English. The unions brought together only parts of firms (often fictitious) dedicated to the production of one good. If a firm had several products, it joined several unions. Once again, we meet an opposition between a product view and a firm view. Because it was born in a context of shortage, this organization is rooted in the concept of product. Nevertheless the firm is the economic and financial centre of decision: accounting and balance sheets are tabulated for the whole firm. This duality of perspective is reflected by a duality of taxonomies for business information: 'branches' group 'homogeneous production units', and the parts of firms producing a commodity. It is a technico-economic taxonomy, used for example in the Leontieff matrix, based on production, consumption and technical ratios. Conversely, 'sectors', or 'kinds of business', more usual for Anglo-Saxon economists, group

whole firms which have the same *principal activity*, even though they may have a lot of secondary activities. It is an economico-financial taxonomy. This duality was at the origin of bitter controversies between French statisticians and economists during the 1950s and 1960s. It was clear that both classifications had coherent meanings, and that they could be supported by good theoretical arguments. But ironically they were a consequence of historical circumstances independent of these arguments. Anglo-Saxon economists never used this distinction, leaving the problem to the 'back room' of statisticians, or at best, to footnotes in large tables.

However, this example of the depth and complexity of the firms, which are present in several markets, according to a combination of economic and financial strategies, still raises many questions as far as statistical practice is concerned. They are not easy to include in a general theoretical model. But they can be worked out in the more precise frame of industrial economy, apprehending the firm as a 'device of coordination' between different models. From such a viewpoint, the market perspective and the production perspective can be analytically distinguished (Eymard-Duvernay 1989).

LABOUR FORCE: FROM CRAFT TO BIG BUSINESS

The labour market has been, for twenty years, an important area of discussion and of renewal of economic theory. What is the status of the labour contract? Is it provisional and temporary or comprehensive and permanent? How do we define the qualities of this particular good: labour? The specificity of the link between the wage-earner and the firm can explain why there is some distance between the behaviours of job suppliers and seekers, and the description of what happens in a purely competitive and fluid labour market. One formulation of this question is given by the efficiency wages theory. Comparisons between internal market and external market try to evaluate costs and benefits of both systems. Economists are naturally inclined towards an endogenous solution to these questions. They modify established models to increase their complexity and test new formulations using facts about wages and qualifications supplied by statistical offices or large data banks.

But it can be interesting to enter this statistical system of description of the labour force through another door: that of its construction and of its relation with particular firm models. The description of objects and persons is a crucial process not only to code and count them in order to make statistics, but also to characterize the whole

coherence of the firm seen as a complex device of coordination. In this perspective, the way of registering, collecting and classifying business information is, by itself, part of a more general model of coordination (Eymard-Duvernay 1989). This is a research hypothesis that would have to be tested on large historical and comparative observations in firms of several types. We shall give here an example about the evolution of the concept of 'skill', which is crucial for defining the qualities of the labour force.

Once again the history of nomenclatures contributes to our understanding. We described above the confusion between the classifications of *products* and *economic activities* (kinds of business). But until the 1940s, this classification was also identical for *individual activities* (occupations). It can be explained by the fact that until this period, the French economy had a large number of very small firms. There was an identification between bread, bakery and baker, or between lock, locksmithing and locksmith. The same classification was used for what is now seen as different notions. The idea of individual activity distinct from the collective activity of the firm came into view only with the growth of big enterprises (it appeared sooner in the United States than in France). It does not mean, obviously, that since the nineteenth century there were no large firms in France. Mining, railroads or department stores were sectors where such firms existed. But the hierarchical model was not general enough to generate a distinct classification of occupations for census takers. Above all, there was no *common language* accounting for these heterogeneous situations.

The transition from the 'craft vocabulary' to the modern standardized language of the collective agreements (concluded between employers and workers unions) is not only characterized by the emergence of this hierarchical and specialized definition of the occupations. There had been, before, at the end of the nineteenth century, another important moment: the construction of a specific legislation of labour, defining the legal status of wage-earners. For example, a new law established compensation for industrial injuries (1892). In this period of economic crisis and social conflicts, were created, almost simultaneously in Europe and the United States, labour offices and bureaux of labour statistics, whose attributes were twofold: preparing new legislation to protect wage-earners from unemployment or injuries (later, old age and disease), and collecting and publishing labour business information. The 'labour question' was, at the turn of the century, a powerful driving force behind the construction of systems of business information.

In France, an *Office du Travail* (Labour Office) was created in 1891, and the old statistical office responsible for the population census, the *Statistique Générale de la France*, was included in this *Office du Travail*. The 1896 census of occupations, described above, was carried out in this context. A survey on wages and duration of work was done in 1893, partly with monographic methods inspired by the Le Play tradition (Luciani and Salais 1990). At this moment the question was less to produce a statistically exhaustive description of the labour force (it was probably impossible), than to give examples of manufacturing situations, supposed to be typical, and to help officials to understand a new world, still largely unknown. More complete statistics came later.

The long transition between the old French economic structure and the new larger firm organization, combined with the technical particularities of the population census, from 1896 to 1936, may explain some specificities of the French occupational classification, compared with the British one. The census made it possible to draw up statistics of establishments according to size and locality. Moreover, it made a distinction between the employers, the manual workers, the clerks, those working alone (*isolés*), and the unemployed. This division was the ancestor of the present-day socio-occupational French nomenclature; the main difference is the addition, after 1950, of groups of *cadres*, top of the wage-earners hierarchy in the firm. This census was applied in the context of an economy of small enterprises, demonstrated by the number of those working alone amounting to 23 per cent of the active population in 1896. These could be peasant farmers, artisans, traders, or sub-contractors engaged in home-working. In this last case, the boundary between employers and self-employed was unclear, partly because of the definitions and rules generated by the relevant, protective labour legislation for this type of work, which was only to develop during the course of the twentieth century.

The way in which occupations were statistically described was also influenced by the fact that it took a long time to appreciate clearly that there were two distinct ways to classify workers: according to the personal occupation of the worker (the tasks and job content involved) and according to the economic sector he or she belonged to. On the occasion of the census of 1911, and for the first time, emphasis was laid on personal occupation. But a carefully defined scale of graded tasks had not been constructed yet and did not appear before the 1940s. The titles of the long-established *métiers* (artisan trades and crafts) predominated in this taxonomy. It was only

gradually that the official occupational nomenclature evolved from a scheme reflecting the dominance of the familiar training and artisanal organization, to a scheme emphasizing the importance of formally accredited degrees of occupational skills or of professional qualification. The latter was sanctioned by a system of graded credentials and was more appropriate to describe the hierarchies of modern bureaucracies and large firms. In this way, the meaning of the notion of 'skill' changed completely, and the declared occupation titles reflect it clearly.

The current French social classification still exhibits these dual origins, with the addition of the hierarchy of wage-earner positions, as they were defined in the collective agreements concluded by employers and employees unions, between 1936 and 1950 (Desrosières and Thévenot 1988). These agreements created a new national common language, largely (but not universally) used. In that way, the field was prepared for establishing the equivalences necessary for national statistics. The relative unification of business practices is a precondition for economically building national business information. Conversely the need for comparative European business information raises, once again, the questions of comparability, or standardization of business classifications and, more generally, social practices and languages. An example may be given with French and British social nomenclatures (Desrosières 1991b).

This comparison is striking, because the British context had nothing to do with the French one (Szreter 1984). Britain's official statisticians were embroiled in a debate over demographic statistics between the hereditarian eugenists and the public-health environmentalists, over the causes of poverty. The social classification of occupations was thereby influenced by an entirely different cognitive context to that known in France, with occupations graded according to a putatively 'natural' hierarchy of the inherited abilities they required. Therefore an occupation was not classified, as in France, according to its location within a productive system gradually changing from an artisanal to an industrial and hierarchically organized structure defined by standardized qualifications. Instead, it was seen as corresponding to a position along a scale of ability and worthiness, according to the terms set by the eugenists in their debate with environmentalists over the supposed deterioration of the British 'race' (Thévenot 1990). The question of the language and the codification of occupational titles generated by the business organization was not considered by the protagonists of this debate. Among the publicly (and statistically) discussed questions, social and poverty

issues took precedence earlier in Great Britain; economic issues like labour-force management, qualification or labour productivity, became prominent later, compared with the historic development in other countries.

Today, the occupational structure of the active population is known from two sides: direct surveys near firms, and surveys near individuals (census or sampling surveys). This information about occupations has two very different uses. The first is economic. It is used for the analysis of a labour force and a labour market segmented according to qualifications, for example for manpower planning. The second is sociological. Occupation is then an indicator of social position, if not of biological ability, as it was for eugenists, not long ago. Occupation is a kind of crossroad information, leading to different sectors of knowledge. But the language for describing occupations is built in the business sphere, and depends on its specific logics. This is why it is impossible to isolate the occupational titles and declarations from two contexts: the productive one in which these titles appear, the social one in which an individual is asked to declare his occupation (Kramarz 1991).

AGGREGATION OR IDENTIFICATION: TWO USES OF INFORMATION

To stay in the 'business-information' world, data about occupations and skills may themselves be used either aggregated, for a whole sector or for the whole nation, in a macroeconomic perspective, or for one firm or one establishment, to support a judgement or a diagnosis about the firm. This duality of uses of business information, either global or attracting attention to one case, is old, as old as the difference between the averages of Quetelet and the distributions of Galton, who invented a way for identifying criminals with fingerprints. But it is now possible to make a statistical *typological* analysis of a population for reconstituting a global consistency of some typical cases, and for helping the diagnosis of a singular case. These techniques, now highly developed and very sophisticated, use expert systems to aid coding decisions. They bridge a gap between the old aggregating use of statistics for macroeconomic or macrosocial analysis, and a 'Galtonian' one, based on distributions and ranks of individuals. But it must not be forgotten, for example in the occupation case, that the identification of a firm cannot be reduced to the statistical structure of the occupational titles, because these titles themselves result from specific interactions, also typical of the

firm's model which is being identified (on this point see Bowker and Star, this volume).

The same kind of remarks may be made about the third important family of business information, after production and occupations, that of accounting and balance sheets. Historically, accounting was born with two different purposes, often corresponding to two distinct professions: public accounting and cost accounting (Abbott 1988). Stockholders and financiers needed reliable information about stock companies. The attestation of capital became, in the second half of the nineteenth century in the United States, an important question, and a special independent profession of public accountants answered this demand. When big business developed with several products ('branches') in one firm, the evaluation of specific costs and benefits linked to each production, for deciding which to keep and which to abandon, became another important question. This management problem was long disputed between accountants and engineers: criteria and purposes of these analytic evaluations were not the same for both professions.

In France, these two developments of accounting probably came later. However, big banks (Crédit Lyonnais for example) had, for a long time, specialized services for analysing firm accounts. But, after 1945, the main impulse for a statistical and aggregated use of these accounts came from the construction of national accounts systems, issued from national-income evaluations (Fourquet 1980). Firms must pay a tax based on 'industrial and commercial benefits', and must declare annual accounts and present a balance sheet to the fiscal administration. Unlike some other European countries, the French statistical office (INSEE) is allowed to use them for statistical purposes, despite the inescapable problems of tax evasion. But these accounts concern whole firms, and give, at best, information on 'sectors' and not on 'branches', as defined above.

Two main statistical sources were therefore available to build national accounts (including Leontieff matrices) and evaluate a gross national product: 'branches' statistics about production and consumption, leading to an added value by branch, and 'sectors' accounts issued from taxation authorities, giving a decomposition of this added value between wages and profits. This duality of sources and the need for a coherent global system partly explain the bitterness of the quarrels between 'branch' and 'sector' analysts. The branch perspective, turned towards product markets independently of actual firms, was adequate for macroeconomic indicative planning as existed in France in the 1960s and the 1970s. Conversely, the sector perspective,

allowing profit and financial analysis, is more consistent with policies addressed to firms, with their strengths and weaknesses. This difference between two ways of using business statistical information presents some analogy with what was suggested above between the policies of Hoover and Roosevelt. The relative decline of Keynesian macroeconomic policies is linked to a new interest in the firm by itself, as a substantial and complex centre of decision.

HOW TO CHOOSE RELEVANT UNITS AND CLASSES?

This is the reason why, for twenty years, efforts have been made by official statisticians for putting together, at the firm level, the different parts of business information: production, consumption, machinery, labour force, accounts, balance sheets, investments, in order to build a complete and coherent statistical system of enterprise. This construction remains largely unachieved, but in France and since the 1970s, an annual enterprise survey progressively extended to most sectors. With questions about turnover, annual accounts, investments and labour force, it has been designed as a bridge between the main dimensions of business information, coming from separate sources. But the reliable management of such an ambitious system needs imperatively a central instrument: an *up-to-date register* of firms. The construction and above all the constant updating of the firm register are the *sine qua non* of a reliable system of business information. In so far as economic life is marked by births and deaths of firms, if not transformation by fusion and absorption, this register is, by itself, the keystone of the whole system.

The existence, the continuous management and the reliability of such a register is a typical case in which cognitive, administrative and political questions are completely entangled, if not the same. As soon as it is decided to build a *coherent system* of business information, many independent actors are involved, in public administration, social-security institutions, banks, etc. Those creating new business enterprises often complain about the number of forms they must complete. In France, the procedure for coordinating and updating the registration of new firms was rationalized, under the impetus of official statisticians. The establishment of a single counter (*guichet unique*) for submitting documents streamlined the process for applicants. At the same time, this new system ensured that the demographic monitoring of firms was put on a more coherent and lasting basis. But because questions asked by different institutions have different purposes, the negotiation of the formulations, in order to

achieve a common form, raises interesting questions about the meanings and the possible different interpretations of concepts, like 'turnover', 'manpower', 'establishment', and even 'enterprises'. As soon as it is actually used for regulating such-and-such administration or economic practice, the identification of business information is never transparent, and can be the matter for a conflict or a negotiation, leading to a compromise.

These kinds of bitter conflicts are also frequent when different countries try to build an international system of business information, as in the EEC or the UNO. For the past ten years, two discussions have been intertwined. How to build a new classification of economic activities (e.g. kind of business)? What are the relevant units to classify? This second question may seem surprising for anybody who would have a rather theoretical view of the business world, but it is a crucial one because there are truly different ways for defining these units. In France there were, for a long time, two clearly distinct notions. On the one hand, the enterprise, as a legal unit, consisting of laws and rules progressively built over a century, was the normal interlocutor of administration and justice, in cases of bankruptcy. On the other hand, the establishment (e.g. plant) was a *local* implantation of a firm, independent of the eventual heterogeneity of its productions. Statistical tables issued by the census, from 1896 to 1936, gave establishment figures. More recently, the financial relations between firms generated another kind of unit: the financial group, which has become increasingly important as central decisions are now taken at this level. However their precise and standard demarcation has been 'hardened' for a shorter time than that of enterprises or establishments.

But even for firms, and plants, definitions are often different from one country to another, and on the occasion of a recent international negotiation about a new common classification of economic activities, this question appeared crucial. Without entering into the technical details of the problem, it raises a more general question, very common in taxonomic discussions between statisticians and social scientists. On the other hand, it may seem very easy and economic, when units are to be coded and counted, or frontiers of classes in a nomenclature have to be defined, to rest on pre-existent administrative or social codification: in this case, the heavy burden of coding is borne by somebody else. Moreover, the statistician may argue, in a Durkheimian way, that this object is *real* as far as it is already firmly inscribed in social practices, even if it appears, from some other perspective, as wrongly or fictitiously defined. Now this kind of

denunciation is frequent, for example from social scientists arguing that such definitions, often built on social compromises, may seem absurd from some theoretical perspective. Sometimes they try to change them, without seeing that their own attempt at coding may become an unworkable puzzle, and that, perhaps, the consequent construction is no more 'real'.

The case of international negotiations is fascinating because different kinds of arguments are mixed up. Explicitly they are cognitive: how to be closest to reality? But this mysterious 'reality' can never be linked to national circumstances, because national interests would appear. The only justifiable arguments must be universal, but they often rest on actual pre-existent social practices. Recent discussion about relevant business units and sectors gave many examples of those subtle cognitivo-diplomatic negotiations. The negotiated dimension of the information may give an alternative view to the realist one for which data is built in order to be 'faithful to reality'. But it must be remembered that the compromise or the agreement resulting from the negotiation may become itself a very hard and therefore real thing, not at all fictitious because negotiated. In this way, it is possible to escape the academic and recurrent debate between realism and relativism (Desrosières 1990).

BUSINESS INFORMATION AND COMMON KNOWLEDGE

Along this journey through some moments of the history of statistical business information, several general themes have arisen, about both business and information. It is only recently that the firm by itself, with its multiple dimensions, has come clearly into view as a relevant topic. Before the 1960s, production, labour force or finances had been registered and described independently, and aggregated in macro-evaluations supporting macroeconomic arguments (at least for official uses). For twenty years, registers and data banks compiling a lot of quantitative business information have been built and are now available. Return trips there and back between macro-descriptions and micro-diagnosis about one firm are now possible; joining both uses has become feasible.

More generally, the growth of big business occurred simultaneously with an increasing objectification of most dimensions of its activities. This shift was hastened by standardization and mass production (i.e. quality of goods, tasks performed by workers in a Taylorian perspective, qualifications and jobs, costs and profit accounts). However, the labelling of business activities did not show the same

rationality as the activities themselves. (Centre d'Etudes de l'Emploi 1987, 1989).

Modes of coordination vary according to type of firm, be it artisanal, mercantile or industrial. Equally, different statistical approaches are connected with each type of organization. Statistical registration best matches an industrial model with its standardized practices. Conversely, the statistical approach is less adapted to economies based on artisanal and informal practices, or to sectors in rapid evolution, in which competition takes place through innovations and creation of new products, rather than through prices as described in classical theory. Because disparate information is difficult to combine, objectification of firm statistics must involve a process of negotiation in which things acquire a common meaning.

Thus, objectification of business activities, essential for 'business information', is itself a complex operation which produces a common account of different activities performed by distinct actors. The creation of this shared knowledge, be it for qualifying goods, tasks, jobs, machines, patents, internal rules, customers or benefits, is necessary to give fixed points or signals, with regard to which actors may coordinate their actions and the accounts they give about them, for themselves and for others (Dodier 1992).

NOTE

1 I am grateful to Lisa Bud-Frierman and Nathalie Greenan for their invaluable help in improving the English of this chapter.

BIBLIOGRAPHY

Abbott, A. (1988) *The System of Professions: An Essay on the Division of Expert Labor*, Chicago and London: University of Chicago Press.

Akerlof, G. (1970) 'The market for lemons: quality uncertainty and the market mechanism', *Quarterly Journal of Economics* 84: 488–500.

Anderson, M. J. (1988) *The American Census: A Social History*, New Haven and London: Yale University Press.

Centre d'Etudes de l'Emploi (1987) *Entreprises et produits*, Paris: Presses Universitaires de France.

—— (1989) *Justesse et justice dans le travail*, Paris: Presses Universitaires de France.

Chandler, A. D., Jr (1977) *The Visible Hand: The Managerial Revolution in American Business*, Cambridge: Belknap Press of Harvard University Press.

Coase, R. H. (1937) 'The nature of the firm', *Econometrica* 4: 386–405.

Desrosières, A. (1990) 'How to make things which hold together: social

science, statistics and the state', in P. Wagner, B. Wittrock and R. Whitley (eds), *Discourses on Society: The Shaping of the Social Science Disciplines*, *Sociology of the Sciences: A Yearbook*, vol. XV, Dordrecht, Boston and London: Kluwer Academic Publishers.

—— (1991a) 'The part in relation to the whole: how to generalise? The prehistory of representative sampling', in M. Bulmer, K. Bales and K. Sklar (eds) *The Social Survey in Historical Perspective: 1880–1940*, Cambridge: Cambridge University Press.

—— (1991b) 'Official statistics and medicine in nineteenth century France: the SGF as a case study', *Social History of Medicine* 4,3: 515–37.

Desrosières, A. and Thévenot, L. (1988) *Les Catégories socioprofessionnelles*, Paris: La Découverte.

Dodier, N. (1992) 'How to transcript medical judgements? Occupational medicine and administrative procedures', in G. Stollberg and J. Lachmund (eds), *The Social Construction of Illness*, Stuttgart: Steiner Verlag.

Doeringer, P. B. and Piore, M. J. (1971) *International Labour Markets and Manpower Analysis*, New York: Sharpe.

Duncan, J. W. and Shelton, W. C. (1978) *Revolution in United States Government Statistics, 1926–1976*, Washington: US Department of Commerce.

Eymard-Duvernay, F. (1989) 'Conventions de qualité et formes de coodination', *Revue Economique* 40,2: 329–59.

Fourquet, F. (1980) *Les Comptes de la puissance. Histoire de la comptabilité nationale et du plan*, Paris: Encres.

Guibert, B., Laganier, J. and Volle, M. (1971) 'Essai sur les nomenclatures industrielles', *Economie et Statistique* 20: 23–36.

Kramarz, F. (1991) 'Déclarer sa profession', *Revue française de sociologie* 32: 3–27.

Luciani, J. and Salais, R. (1990) 'Matériaux pour la naissance d'une institution: l'Office du Travail (1890–1900)', *Genèses. Sciences sociales et histoire* 2: 83–108.

Mayr, O. and Post, R. C. (eds) (1981) *Yankee Enterprise. The Rise of the American System of Manufactures*, Washington: Smithsonian Institution Press.

Mirowski, P. (1989) 'The probabilistic counter-revolution, or how stochastic concepts came to neoclassical economic theory', *Oxford Economic Papers* 41,1: 217–35.

Morgan, M. S. (1990) *The History of Econometric Ideas*, Cambridge: Cambridge University Press.

Simon, H. A. (1951) 'A formal theory of the employment relationship', *Econometrica* 19,3: 293–305.

Stiglitz, J. E. (1985) 'Information and economic analysis: a perspective', *Economic Journal* 95: 21–41.

Szreter, S. (1984) 'The genesis of the Registrar General's classification of occupations', *British Journal of Sociology* 35,4: 522–45.

Thévenot, L. (1984) 'Rules and implements: investments in forms', *Social Science Information* 23,1: 1–45.

—— (1990) 'La politique des statistiques: les origines sociales des enquêtes de mobilité sociale', *Annales ESC* 6: 1275–300.

Vining, R. and Koopmans, T. C. (1949) 'Methodological issues in quantitative economics', *Review of Economics and Statistics* 31: 77–94.
Volle, M. (1982) *Histoire de la statistique industrielle*, Paris: Economica.
Williamson, O. (1985) *The Economic Institutions of Capitalism: Firms, Market, Relational Contracting*, New York: The Free Press and Macmillan.

D83 LP6 181–213

9 Knowledge and infrastructure in international information management

GLOBAL

Problems of classification and coding[1]

Geoffrey Bowker and Susan Leigh Star

M19 L23

INTRODUCTION

Marx has referred to technology as 'frozen labour' – work and its values embedded and inscribed in transportable form. Modern information technologies similarly embed and inscribe work in ways that are important for policy-makers, but which are often difficult to see. Where they are used to make decisions, or to represent decision-making processes, such technologies also act to embed those decisions. That is, the arguments, decisions, uncertainties and processual nature of decision-making are hidden away inside a piece of technology or in a complex representation. Thus values, opinions, and rhetoric are frozen into codes, electronic thresholds and computer applications. Extending Marx, then, we can say that in many ways, software is frozen organizational discourse.

The purpose of this paper is to explore this idea theoretically, taking stock of some of the issues in the sociology of technology, and to reflect on how they might contribute to research in organizational policy about information systems. We use as an example a case study of the history of the International Classification of Diseases (the ICD), a coding scheme currently administered by the World Health Organization (WHO). This scheme is an important infrastructural component of medical and epidemiological software. It is increasingly important, as well, for the financial and administrative components of medical care, as it is used (in a number of different forms) to encode reimbursement, in cost assessments and in the allocation of expensive equipment on the basis of diagnostic need.

The ICD here is an example of an attempt to collect global information across a number of federated sub-organizations, as well as a number of other sources. Like state censuses and many forms of business and governmental statistical data-collection efforts, it is

protean in its effects on knowledge in both the private and public sectors. That is, people use the ICD and its knowledge in a myriad of ways, including developing Diagnosis-Related Groups (DRGs)[2], medical software, assessing equipment and personnel needs, and reporting vital statistics. These in turn have a profound impact on health-care costs and business policies (see Geist and Hardesty 1992 for a recent discussion of this in the American case).

The ICD and similar categorizing schemes are thus important for business historians in two ways: first, as an example of the practical and theoretical difficulties and challenges inherent in modelling multinational information collecting; and second, as an example of how management and decision-making tools become part and parcel of organizational structure. We offer this paper as a contribution to the emerging community of interest joining management information systems, social history of statistics and classification, sociology of technology, and studies of infrastructural development (Hughes 1987; Boltanski and Thévenot 1987, 1991; Desrosières 1988, Ch. 8, this volume; Yates and Orlikowski 1992; Star 1989c, 1991, 1992).

The ICD is about one hundred years old. It has been revised nearly every ten years since the end of the nineteenth century. It is distributed as a booklet, or as a component of medical record-keeping software, to public-health offices, hospitals, insurance companies, health-accountancy firms and bureaux of vital statistics throughout the world. It contains numbers which correspond to causes of death or illness, and algorithms for arriving at those numbers in complex cases involving more than one disease or cause.

In a sense, the ICD is the backbone of a sophisticated organizational policy and a decision-making support tool, as well as a form of large-scale organizational memory. On the basis of data collected using the ICD system, decisions are made about allocation of resources, whether and how to control epidemics or endemic illnesses, and whether there are shifts in population based on infant mortality rates, etc. Unfortunately, the ICD has received little analytic attention from social scientists.[3]

THE NATURE OF LISTS AS DECISION-MAKING TOOLS

List-making has frequently been seen as one of the foundational activities of advanced human society. Thus Jack Goody (1971, 1987) has argued that the first written records are lists (of kings, of equipment). Michel Foucault (1970) and Patrick Tort (1989) have, in their different ways, claimed that the production of lists (of

languages, races, minerals, animals) revolutionized science in the nineteenth century and led directly to modern science. Latour (1987) has proclaimed that the prime job of the bureaucrat is to compile lists, which can then be shuffled and compared. These diverse authors have all turned their attention away from dazzling end-products in the various forms of Hammurabi's code, mythologies, the theory of evolution, the welfare state, and so on. They have instead looked at the work involved in making these productions possible. They have dusted off the archives and discovered piles and piles of lowly, dull, mechanical lists.

List-making is foundational for coordinating activity distributed in time and space. Consider an apparently simple problem of coordination that children in many cultures solve routinely: the treasure hunt. In this game a list of objects is made, usually by an adult, and teams of children are each given duplicate lists. The first team to bring back all the items on the list wins. Even a local, improvised list, such as this, entails judgement calls: objects should be difficult enough to challenge the children's ingenuity, but not impossible; they should not require impossible resources (e.g., no objects requiring use of a car to fetch). Typically they are things that are odd but not impossibly rare – a copy of the front page of the *New York Times* from 4 June 1964; a green high-heeled left shoe. Teams may decide to coordinate their internal work by assigning each person an item, or working in pairs, or moving as a group, and so on.

When lists are used to coordinate important work that is distributed widely over time and space, a correspondingly complex organizational structure and infrastructure must evolve (Yates and Orlikowski 1992). Negotiations over the content of the list become reified – frozen – and often take quantitative form, especially if the items are numerous, costly, or critical for other operations. The judgement calls are still there, but now involve multiple actors, including individuals, organizations and technologies. The decisions about division of labour remain, but now entail bureaucracies as well as spot judgements. As all the authors cited above have concluded, large-scale coordinated work is impossible without lists. As well, those lists entrain whole series of substantive political and cognitive changes in the classes they inventory.

The ICD, as a functioning means of coordinating information and work highly distributed over space and time, contributes several valuable lessons to understanding the management and use of information technologies in very large multinational organizations:

first, there is a permanent tension between attempts at universal standardization of lists, and the local circumstances of those using them;

second, this tension should not, and cannot, be resolved by imposed standardization, because the problem is recursive;

third, rather, from the point of view of coordination, *ad hoc* responses to standardized lists can themselves be mined for their rich information about local circumstances, in turn, information technology might be tailored to support those needs, not subvert them;

fourth, this type of list is an example of the sort of object which must satisfy members of communities or organizations with conflicting requirements. In its creation, and later in its use, the complex list is a kind of knowledge representation particularly useful for coordinating distributed work, which often contains requirements of this sort. Some, ourselves among them, would argue that they are *necessarily* conflicting (Hewitt 1985, 1986; Star 1989a).

The problems of such knowledge in very large, distributed organizations are increasing as multinational firms confront local variation and definitions of knowledge in their subsidiaries in different countries. The problem here can be seen as generic to all such efforts where diversity is the central issue in representing information.

THE IMPACT OF THE ICD

To continue in a foundational vein, the ICD can be seen as one of the tools bound up in the origins of the welfare state (Ewald 1986): the epidemiologists and government statisticians who originally drew it up were concerned with large-scale public-health measures. It has silently accompanied all major epidemiological work this century.[4]

The ICD has played a key role in determining the outcome of epidemiological, public-health and economic arguments. We will look at the way it has been used by different groups, constituting both a common and a customizable object for these groups. We will look at the tension between the desire to standardize (so as to be able to perform bureaucratic functions such as comparison over time and space, produce algorithms, compute, etc.) and the drive of each interested party to produce and use its own specific list. We will also examine the tension between attempts to make a universally standard list and the idiosyncrasies and local circumstances of users. Both

these tensions speak to the nature of all knowledge-based informatic policy and management tools.

To develop this analysis further, let us first inventory the different classes of informational conflicts involved with building up and using the list, and examine the types of informational needs and structures involved in each case. At the same time, we will examine some associated problems drawn from the list's history.

International conflicts

One of the values of a list like the ICD is that it can be used in transnational comparisons, especially where there are radical local differences in belief, practice, and knowledge representation. This is necessary for epidemiology, in that one may trace specific environmental and nutritional factors involved in particular diseases, track epidemics and impose quarantines.

These advantages can only be fully exploited if the various sub-organizations agree on how to collect and code information. A continuing problem has been that some countries have not always sent in their information promptly (a problem finding its parallel with the reports sent to central office by subsidiaries). In the 1920s, France and Portugal were notably slack. Further, once the information comes in, it is often of variable quality – countries with large rural populations find it difficult to give the same sophisticated medical treatment of each case, as heavily urbanized, western countries (La Réunion du Conseil de la Socíeté des Nations 1923). At one stage in the USSR, no attempt was made to compute causes of death in places with less than 10,000 inhabitants (CH/Experts Stat/78)!

Different states have different bureaucratic structures – for example in the nineteenth century, the statistical system was run by a central service in Italy but was broken down by province in France (Bertillon 1887). The regulations regarding death certificates used have made an appreciable difference to the type of results the ICD achieved. Thus in Germany in the 1920s there was no separation between the civil statement of the cause of death and the cause of death issued for statistical purposes. In Switzerland, the statistical cause of death was confidential, making it much easier for doctors to cite causes that might distress relatives (and upset insurance companies). Thus when Holland switched over to the confidential system in 1927: 'There was a considerable increase in Amsterdam of cases of death from syphilis, tabes, dementia paralytics, aneurism, carcinoma, diabetes, disease of the prostate and

suicide, while deaths from benignant tumors and the secondary diseases such as encephalitis, sepsis, peritonitis etc showed a falling-off' (CH/Experts Stat/34).

Further, different cultures place differential emphasis on causes of death. A recent case of this is a controversy about Japan's low rate of fatal heart attacks. A traditional reading of the list suggested that this statistic is due to nutritional or environmental factors peculiar to that country – level of fat in the diet and so on. Recently, however, some epidemiologists have suggested that the 'cause' may well be that heart disease is a very low-status cause of death within Japanese culture, suggesting as it does a life of physical labour and a physical breakdown. Accordingly, what we would call heart attacks often get described as strokes, since an overworked brain is more acceptable. When this is factored in, they suggest, there is no discrepancy in Japan's figures. These national differences are complicated by the facts that some diseases present differently in different countries. AIDS is one such; malaria another. For the latter, E. J. Pampana noted in an article entitled 'Malaria as a problem for the WHO' that:

> At a first glance, malaria does not appear to have an international character at all; one could almost say that no other disease is so strictly dependent on local conditions. Malaria might, in fact, almost be called a nationalistic disease, because it takes from the country its very characteristics, as does its folklore. These very local aspects of malaria epidemiology are the bricks with which the science of malariology is built.
>
> (WHO Archives, 453–1–4)

Different national schools of medicine may disagree about issues such as simultaneous causes of death. One WHO committee noted that there were indeed such differences; and that if there were no agreement by 'reason', then countries would vary according to: 'facts of pathology (or) clinical medicine, (or) public health importance' (WHO Archives, 453–1–4: 11). It recommended that the different countries produce a table of contributory causes so that a comparison could be made. The problem was huge, however. In the Census Manual of the International List of Causes of Death there were 8,300 terms, which represented 34 million possible combinations. If half of the terms could enter into combination, then an assignation of priority in all possible cases would involve 61 volumes of 1,000 pages each (CH/E STATS/34: 10–11).

Finally, handling of the ICD has been politically charged. Originally, it was run by the French Office Internationale d'Hygiène

Publique (OIHP); and was for the French government a sign of their natural diplomatic leadership. When the League of Nations started to gain control of the production of the list, one British diplomat noted that: 'an influential clique in the French Foreign Office is moving heaven and earth to retain the Office Internationale unaltered' (Société des Nations, Box R822). The United States became a key participant when it refused to join the League of Nations, leaving the OIHP as broker between the United States and the League of Nations. They tried to squeeze out the International Institute of Statistics as advisers, leading the director of that organization to complain that: 'The new masters of the world are laying down their law, without any consideration for the rights of others and for an international organization that had received universal respect to that time' (WHO Archives, 455–3–3).

Relationships between developed and less-developed countries figure in the construction of the ICD. For the former, with access to the latest computer equipment, some kind of state-of-the-art expert system could handle more data and detail, more flexibly, than has ever been possible in the past. However, for Third World members of the WHO, lacking in a computer infrastructure capable of implementing the sophisticated software, the list would be useless. Even were it possible technically, this level of granularity is unnecessary for countries where death is overwhelmingly caused by infant diarrhoea via contaminated water supplies. Until these issues are solved, who cares about the incidence of rarer diseases? The question is not rhetorical – other member nations *do* care, since they want to be able to trace the aetiology and development of their own epidemics (flu, AIDS, etc.) throughout the world.

So international cooperation was hampered within each nation by the diversity of ways of recording and reporting, by local cultures regarding the prestige of certain diseases, by local medical cultures and by the different national character of some diseases. It was hampered between nations by the issue of control of the prestigious ICD and by the medical needs of the different nations. The public-health policy-makers that were involved before this apparently simple, homogeneous list could be compiled and implemented included government officials, statisticians, anthropologists, medical analysts, epidemiologists and diplomats. Again, we can see parallels with power struggles, control and containment in the multinational firm and its information management.

Government: the state vs the individual

Another series of actors emerge when we turn to the relationship between the state and the individual. There are a number of moral and political categories here which directly affect the structures of information. The classification of death by suicide is a good example. Early in this century, many doctors complained about the detailed breakdown of this category, which had 'no prophylactic value'. Statisticians responded that the details should be recorded 'for their sociological interest and for the police', defined by the judiciary, not medicine. This incorporated some moral and political distinctions. Thus: 'In the case of collective suicides, you have to count as many suicides as there are people over the age of majority. Minors have to be considered victims of murder' (Commission Internationale Nomenclature Internationale des Maladies: 118). Similarly, death by starvation was said to be a 'crime' if children suffered it; a 'misfortune' if an adult cause of death (Commission Internationale Nomenclature Internationale des Maladies: 116–17). Similarly, when criminal abortion was defined in a fairly undifferentiated way as homicide (whereas legal abortion had its own category), it was hard to get statistics about it. Similarly, stillbirth was a political and religious category that varied by nation and by brand of Christianity. Should a foetus that had never breathed (or tried to breathe) be recorded as a death? If so, it would both contribute to infant-mortality statistics *and* have a soul; if not, the miscarriage would just be recorded under the morbidity tables.

Conflicting needs of doctors, epidemiologists and statisticians

How accurate does information need to be? The question is not a trivial one as the opportunity and transaction costs involved in collecting information multiply with precision. In the case of the ICD, doctors saw the work of collecting data as trading off against clinical resources; statisticians wanted as much accurate information as possible. The task of filling in the death certificates ordinarily falls on the doctor. She or he does not necessarily see the value in filling in a complex form to the degree of accuracy required – after all, this patient is dead, and is the time not better spent on the living?

When it comes to use of the tables produced with the list as a basis, in general: 'practicing specialists want more categories and urban statisticians want less' (Société des Nations, Organization d'Hygiène, Commission d'Experts Statisticiens, CH/Experts Stat./1–43: 1–2).

Here, specialists wish to know the breakdown of each disease strain, whereas the public-health urban statistician wants broader, action-oriented categories like nutritional deficiencies, environmental factors that could be changed, and so on. This has at times led to a double bind:

> So-called administrative statistics have no value in the eyes of practitioners, who as a result are completely uninterested in it; whereas unless these practitioners provide exact data, then the scientific value of administrative statistics has to be called into question.
>
> (Société des Nations, Organisation d'Hygiène, Commission d'Experts Statisticiens, CH/Experts Stat./1–43: 2).

To continue to draw the parallels with business, one hears clear echoes here of the infamous tension between R & D on the one hand, and marketing on the other, in terms of need for precision.

The different groups spoke to issues at the core of the ICD. Statisticians, for example, wanted the first ICD to have only 200 categories, since a statistical 'table' as used in censuses, etc. could only be approximately 200 lines long. For them, lists had to be stable over time and space, for comparability. 'This is why diseases must be classed according to their seat and not their nature or their cause. Because the seat is much more easy to determine than the nature' (Commission Internationale Nomenclature Internationale des Maladies: 11). They stressed that the role of the list-makers was not to produce 'philosophy' but to make a 'truthful' and 'comparable' list. The Spanish authorities wanted the list of general diseases to be set out according to how public authorities could react, breaking them down as follows:

general and sporadic
epidemic
imported
common to people and animals
professional intoxications.

(Commission Internationale Nomenclature Internationale des Maladies: 17)

Another set of statisticians wanted to give precedence to social-biological factors (CH/Experts Stat/80: 4).

'Violent death' should move up the list, since this would: 'settle various doubts . . . as to whether consequences due to visible external causes are to be classified here, or, for example, under

infectious diseases (a case in point is infectious diseases of wounds)'. There should be a subdivision for diseases for which statistics were required under international conventions (e.g. lead poisoning) (CH/Experts Stat/80: 4).

As we have gone through the different categories, we have been getting closer and closer to Foucault's (1970) famous list, which he comfortably relegated to ancient China. The ICD is not so much a list of causes of death as a series of dynamic compromises between a wide range of players in a number of different dimensions – perhaps not unlike an organization chart or a labour contract. Or, as one observer noted:

> In short, the nomenclature of diseases and of causes of death established for the needs of statistical organization constitutes a sort of contract between the two organizations who are charged with statistical works – that is to say the service who makes the observations and that which produces statistics with the help of these data.
>
> (CH/Experts Stat/43: 3)

Industrial actors

We have already said enough to indicate that many people from diverse social worlds had a stake in how the ICD was compiled and used. Three other significant groups were:

1 Insurance companies. These groups wanted a breakdown of the ICD statistics in such a way as would be useful for them: 'For example, there should be groups corresponding to the age at which direct compulsory sickness insurance begins, and the age at which compulsory old-age insurance starts' (CH/Experts Stat/80: 3). Since this was different for different countries, this would have been hard to apply.

2 Industrial companies. Some of the first groups to produce lists of causes of death were from the vast German chemical companies of the late nineteenth century. For them, relevant variables were whether the deceased had touched/not touched certain compounds, had worked inside/outside, etc. Again, we have here a different set of variables from those of interest to other groups.

3 Pharmaceutical companies. The claims that can be made for different drugs is in part a function of the list of diseases. A classic

case of this is cited by Bijker and Law (1992): because of religious restrictions, the Spanish pharmacopoeia redefines what we would describe as birth-control pills. These have a side-effect of high blood pressure; the pills may be prescribed as a treatment for hypotension with the technical side-effect of inhibiting birth. (Note what is likely to happen to the incidence of hypotension in such cases.) Or it can work inversely. One of us formerly had a student who was a representative for a large drug company. A major part of her job was interviewing doctors about whether any of their patients had got better from one disease while taking one of the company's medications for another. If yes, that disease might potentially be added to the list of indications for the illness. The student said that she was constantly pressured by her superiors to 'broaden her indications'.

Here again, there is a trade-off between market pressures and regulation, which need conflicting levels of restriction.

We will not attempt here to list all the various actors that we have seen involved in compiling and implementing the ICD, but the matrix in Table 9.1 summarizes what should be obvious: something has to give; the list cannot be homogeneous, neutral and appeal to all parties. This is typically the case for tools and objects which inhabit a number of different social worlds simultaneously (Star and Griesemer 1989; Star 1989b). King and Star have examined this problem for the decision-making process in organizations, and its implications for designing organizational decision support (King and Star 1990).

We will now turn to the solutions to the problems of multiple membership that have been explored throughout the history of the ICD.

POLICY INSCRIBED INTO THE ICD

A number of very bright people have long been working on the difficulties posed by the ICD. We will in this section inventory working solutions to the above problems at the level of the negotiations about the ICD. We will then be able in our concluding section to draw some connections with how the list is used in practice, and comes to inform policy downstream and locally. The solutions proposed here are generic ones commonly appearing wherever diverse information sources must be reconciled into categorical schema.

Table 9.1 Some conflicting needs of the ICD

	Information needs	*Problems*
International public-health data collection	Precision	Religious and cultural customs
	Thorough coverage by case	Incompatible medical systems
	Timeliness	Ownership and administration of data
	Consistency	Different granularity needs of users
Government	Legality	Matching legal and medical categories
	Vital statistics for planning	Crimes unreported for various reasons
Doctors, epidemiologists and statisticians	Diagnostic	Statistical vs clinical approaches
	Preventative	Different hierarchies of multiple causes
	Predictive	Early detection vs clear clinical case
Industrial	Targeting special groups	Different aggregations of data
	Industrial pathogens	
	Drug impacts and indications	Shifting market needs

Distributed residual categories

Our first solution – garbage categories – might seem to be no solution at all, but rather a studied avoidance of the problem. It does, however, offer some interesting insights. By 'garbage categories' we mean that array of categories where things get put that you don't know what to do with – the ubiquitous 'other'. In mid-nineteenth-century Paris, more than 10 per cent of causes of death were 'other causes' (Bertillon 1906). In Berlin at the turn of the century, doctors were reluctant to provide valuable morbidity information. Thus one table gave acute bronchitis 1,571, chronic bronchitis 225, bronchitis, without any other qualifier, 12,844 (CH/Experts Stat/88: 8).

There were three general causes for the creation of garbage categories. The major sub-category 'undefined diseases' was used: 'either because there was not enough information or because the disease was badly characterized or finally because the doctor failed to formulate a complete diagnosis' (Commission Internationale Nomenclature Internationale des Maladies: 128).

It would be extremely difficult to envisage a time when there would

be no need for these categories. Their management has been a constant thread throughout the history of the ICD. A major feature of this management has been their distribution throughout the list. Thus at the time of the first revision of the ICD, the United States representatives suggested getting rid of the categories 'eclampsia' (non-puerperal) and 'children's convulsions', since they were ill-defined (pun unavoidable). The committee rejected the suggestion, since it would lead to the attribution of too many 'unknown causes . . . and this would discredit the statistics' (Commission Internationale Nomenclature Internationale des Maladies: 62). Or again, the vague 'haemorrhage' was kept, with a view to 'not over-inflating the figures concerning badly defined diseases' (Commission Internationale Nomenclature Internationale des Maladies: 73). This distribution went to the lengths of distinguishing between two types: 'other diseases' and 'unknown or badly defined diseases': 'Proposed conclusion: Each of these two rubrics is very important. The latter in particular indicates what is missing from the other figures in their approach to truth' (Commission Internationale Nomenclature Internationale des Maladies: 138). The need to distribute was urgent – Jacques Bertillon estimated that over half the causes of death would be 'other' in Paris in 1900 if all the residual categories were gathered together (Commission Internationale Nomenclature Internationale des Maladies: 5).

These categories, then, tend to fix the maximum level of granularity that is possible. Their advantage is that they can signal uncertainty at the level of data collection or interpretation – while forcing a more precise designation could give a false impression of positive data. The major disadvantage is that the lazy or rushed doctor will be tempted to overuse 'other'. By their nature, forms of this kind are only manageable if there is a zone of ambiguity written into them: in this case, precise definitions would drive a wedge between doctor, statistician and epidemiologist.

Heterogeneous lists

Throughout the history of the ICD, there has been a great deal of debate about whether it constituted a nomenclature or a classification. The difference is that a nomenclature is merely a list which does not give any indication of cause whereas a classification gives causes. The advantage of a nomenclature is that it can remain more stable over time. For example, a nomenclature based on the 'seat' of the disease can list a series of indications which can then be used at a

second degree of analysis to re-diagnose in line with current theory. Systemic diseases – like AIDS or systemic lupus erythematosus – can be tracked this way, even though the category might not have existed at the time the original diagnosis was made. Classifications are more convenient immediately, but change every few years in time with the development of new medical techniques, etc.

Intuitively it might seem desirable to have a single well-defined governing principle for the ICD. However, as for garbage categories (and for the same reason – the array of actors involved), the solution that has emerged over time has had the appropriate level of ambiguity. The list has been as heterogeneous as possible to enable the different actors to find their own concerns reflected. This has resulted in the fact that although the list is in appearance homogeneous, there are at least four classificatory principles involved:

1 topographical: this refers to the seat of the disease, which part of the body it manifests in;
2 aetiological: this refers to the origin of the disease – genetic, viral, bacterial, etc;
3 operational: this refers to the responses to certain tests – without there being a necessary one-to-one correspondence between test results and a given topographical or aetiological feature (though in general one or the other is asserted). HTLV vs HIV is a case in point. HTLV was defined in terms of a positive reaction to a test searching for antibodies. When what we call HIV initially produced the same reaction, Gallo classified it as an HTLV – even though the virus had not been isolated;
4 ethical/political: we have seen examples of this above. The definitions of stillbirth, abortion, suicide, iatrogenesis and euthanasia, for example, are the outcome of ethical and political decisions.

Parallel different lists

Frequently over the course of the history of the ICD, different groups have found that the list just did not serve their purposes, and so they have modified it. This could happen in a country with a different range of medical problems. For example, the first ICD was drawn up partly through a comparison of the Tables of Mortality of six European countries. Naturally, then, little room was left for a whole range of tropical diseases, and so African countries had to produce their own modifications. Or again, different users of the list might find that their exigencies were not met by the current one – for

example, medical-insurance companies have often produced their own versions.

As with many other attempts to standardize (computer languages come to mind), each time an international standard is laid down – every ten years in our case – there is an immediate efflorescence of modifications. Rather than lose control of this whole process, the ICD committee has chosen to issue rules for how the list is to be modified. This gives them a degree of control at the second level that they have lost at the primary one. The advantage of this secondary control is that it gives an algorithm for working back from the modified list to the ICD itself.

Full complementary localization

In some instances, it has been suggested that the list itself be ignored and detailed local studies be carried out instead. Thus the Registrar General of England and Wales, responding to the call for an International List of Causes of Morbidity to complement the ICD, recommended: 'large sample investigations into particular groups of morbid conditions' instead of international classification, which would impose an order which masked the inherent vagueness of diagnosis (CH/Experts Stat/87). He noted that even for notifiable infectious diseases, intra-national (let alone international) comparison is difficult, and argued that doctors were too diverse a group to unite internationally around a given list:

> Dr Roesle is tacitly assuming that the flagrant non-comparability of existing morbidity statistics is chiefly due to diversity of classification. The cause of the divergence may lie deeper, and may reflect important differences in the points of view of the practitioners themselves.

His conclusion was that time spent on classification was wasted. For example, he wrote of breast cancer:

> The fact that this disease does not greatly contribute to the *statistical* incidence of morbidity, is an evil not capable of remedy by any international rules of classification – it can only be cured by raising the standard of hygienic education; that of the public at least as much as that of the medical profession.
>
> (CH/Experts Stat/87)

This solution is a further step from the ambiguity written into the list of our first two and the diversity of lists of the third. It suggests

that no list at all is valuable. Again, however, from the point of view of the ICD this denegation in fact serves to strengthen the boundary object: through open recognition of the tension between the local and the international/universal, the ICD has been continually tested and its limits set. Boundary objects do not claim to represent universal, transcendent truth – they are pragmatic constructions that either do the job required or recognize their own inability to do it (Star 1989a).

Convergent bureaucracy

Not all the work that has made the ICD more applicable has been done internally through modifications to the list. Indeed, one background factor that has had a great impact has been the convergence of international bureaucracy. What we mean by this is that throughout this century in general people have become more and more used to being counted and classified – and public organizations have become more and more adept at the necessary procedures. Inhabitants of rural areas and of Third World countries are less likely to slip through the net now than fifty years ago. It is much less likely anywhere that it is the village priest who determines the cause of death.

We introduce this factor as a reminder of the historical and contingent nature of universally applicable lists. In a related domain, Alain Desrosières (1988) has shown beautifully how census breakdowns of the populations of Germany, France and England have remained closely tied to the history of work, trade unions and government intervention in those countries. We suggest that as the ICD 'naturally' becomes more universally applicable, this is partly the result of the hidden spread of western values through the application of our own bureaucratic techniques. These techniques appear rational and general to us, but when looked at in detail prove highly contingent.

Computerization

From the early 1920s with the use of Hollerith cards and Powers machines, the history of the ICD is interwoven with that of computing. The chief advantage that computing is offering today to the ICD is maintaining uncertainty at the level of closure on analysis. When the list involved a relative handful of categories arrayed along one dimension, then a whole series of decisions were forced –

whether the disease was environmental (e.g. of industrial origin), genetic or viral, etc. Even when the maximal degree of ambiguity was kept, it was impossible to compare large bodies of data simply because the original wealth of material could not be maintained. Thus, for example, the difficulty in tracing AIDS historically – occasional outbreaks of Kaposi's sarcoma were too rare, and often just disappeared into the statistics in some sort of 'other' category. Now that more numbers can be crunched, and more axes added to the disease descriptions encoded by computers, the time of decision can be held off, and the prospect of true comparability is a real one.

The growing literature in organizational and managerial computing and its impact on knowledge, attests to the importance of ambiguity as an organizational resource (see Kraemer, Dickhoven, Tierney and King 1987, for an example using computerized information modelling; Pinsonneault and Kraemer 1989 review this literature for decision support). Since March and Simon's first conception of satisficing in the absence of universal, complete, knowledge, increasingly sophisticated models and metaphors have been advanced to attempt to address this issue (see Morgan 1986 for a review).

Standardized forms

The goal of standardizing the ICD is, we have shown, by no means equivalent to rendering it unambiguous. Consider, for example, the following definition of a cause of death produced by a committee seeking to standardize death certificates:

> A cause of death is a morbid condition or disease process, abnormality, injury or poisoning leading directly, or indirectly, to death. Symptoms or modes of dying, such as heart failure, asthenia, etc are not considered to be statistical causes of death.
> (WHO Archives, 455–3–4, 31/3/48)

The committee proposed a uniform death certificate with several blanks to be filled in for causes and symptoms.

It will be clear from all we have written, first, that standard forms are essential in order for the ICD to work, and second, that these standard forms cannot be over-precise or people will not be able to use them. That is the fault of this standardized death certificate – it attempted to make the determination of the real cause of death at the time of certification. This entailed asking busy doctors to do work they had neither interest in doing nor often any ability to do. It entailed making choices that were more historically contingent than

the ICD itself, which allowed a deal of flexibility by not itself making *any* casual claims. *Standardization procedures must be tailored to the degree of granularity that can be realistically achieved* (Fujimura 1987; Star 1991).

USING THE ICD: LINKS BETWEEN DESIGN AND PRACTICE IN THE ORGANIZATIONAL INFRASTRUCTURE

Having made it clear that there are many unsettled arguments about the design of the ICD, let us look for a moment at the practices associated with its use by people certifying death and illness. None of this will come as a particular surprise to sociologists involved with quality control and survey-research methods. For many years they have been exploring the gap between representations, codes and the practices of filling out forms: Cicourel's (1964) groundbreaking critique of methods in survey research in the early 1960s, for example; Bitner and Garfinkel's (1967) exploration of 'Good organizational reasons for bad organizational records' extends the analysis. There's a lovely and extraordinarily honest article by sociologist Julius Roth that explores some of the practices of coders in survey research:

> After it became obvious how tedious it was to write down numbers on pieces of paper which didn't even fulfill one's own sense of reality and which did not remind one of the goals of the project we all in little ways started avoiding our work and cheating on the project . . . We had a special category in our coding system, a question mark, which we noted by its symbol on our code sheets whenever we could not hear what was going on between two patients. As the purgatory of writing numbers on pieces of paper lengthened, more and more transcripts were passed in with question marks on them.
>
> (Roth 1966: 190)

Lest one think that this would be picked up at a later point:

> In order to ensure the reliability of our coding, the research design called for an 'inter-rater reliability check' once every two months. We learned to loathe these checks; we knew that the coding system was inadequate in terms of reliability and that our choice of categories was optional, subjective and largely according to our sense of what an interaction is really about, rather than the rigid, stylized and preconceived design into which we were supposed to make reality fit.
>
> (Roth 1966: 191)

He goes on to describe how the coders conspired together to come up with an inter-rater reliability coefficient of 0.70 on 'checking days' in order to be able to keep the research going (Roth 1966: 191).

Roth argues that this behaviour is not unethical, but an inevitable consequence of delegated, large-scale, alienated survey-research labour. Recent studies of ICD-using coding practices, which are also highly delegated from the point of view of the WHO and the US Public Health Service, and largely *unimportant* from the point of view of certifying physicians, appear to highlight the same sort of phenomenon.

Mick Bloor (1989) studied the practice of death certification by physicians. He notes that the practice is low-status, isolated work; it is not checked or queried very much at all, even though there are legal provisions to do so. Even in the case of autopsies, the hospital pathologist does not review the death certificate – his or her job is a clinical or research one! It is also unevenly distributed among medical practitioners. Out of 482 doctors in one Scottish city he studied, 31 doctors had signed nearly a third of all the death certificates. He found that there were enormous variations. There was only 61 per cent agreement on the diagnosis of the underlying cause of death between clinicians and pathologists; other studies have found that inter-rater reliability varies with the deceased's age and condition, the deceased's social class, the practitioners' nationalities, and their ages.

Nicolas Dodier has shown how medical judgements, including various ICD-encoded diseases, are actually *transcribed*. Again, as one would expect, he found many points of tension and resistance between the clinicians filling out forms and the administrative needs of the information-gathering bureaucracy (in this case tracking occupational illnesses). He says:

> Occupational doctors' vocabularies are tied to the local histories of the workplace. Occupational physicians' access to objects is mediated by the instruments and the terms that people: employers, employees, representatives of personnel themselves use in the workplace . . . there is no guarantee that local vocabularies for identifying reality coincide with administrative nomenclatures, except in the rare cases where the regulatory language is put into use by the employees and the employers themselves. There is, therefore, a conflict between the attention that doctors give to local universes and the standardized administrative definition of pertinent objects for judgement.
>
> (Dodier 1990: 6)

He goes on to say that sometimes the doctors treat the coding schemes as black boxes, sometimes they argue with them and bring in other expertise, and at other times the exigencies of time simply mean they code in an *ad hoc*, even arbitrary fashion.

POLICY IMPLICATIONS

A not unreasonable response to the combined ambiguities of design and certification practice in the ICD would lead one to throw up one's hands and walk away from any sense of data quality or certainty about the meaning of the ICD statistics. And yet from the point of view of very large organizations, information, and diversity, this would be to abandon as well a great deal of rich information about the ways in which software and its attendant categories become 'frozen policy'. The question before us is extremely complex. Very large, highly integrated computing systems are currently being built which daily transmit vast amounts of information around such networks globally. These tools, and the situation described here, demand new conceptual approaches for understanding the nature of this infrastructure. Two major lessons have emerged from this case study of the ICD:

1 It is unrealistic and counter-productive to try to destroy all uncertainty and ambiguity in these sorts of infrastructural tools. By their very nature, classification systems need appropriate degrees of both in order to work – only in a totally uniform world (*within* a given speciality) would it be even conceivable to try to impose total precision (Serres 1983). Rather than root out all instances of ambiguity, analysts of standardized lists should instead seek clearly and consistently to define the degree of ambiguity that is appropriate to the object in question.

2 No such tool can be defined once and for all. It is the product of continuing negotiation and change. We have noted three spurs for such change. First, there might be a change within one of the communities of practice that has a say in the definition of the tool. Thus, medical specialists might come up with a new test that causes a reclassification of a number of diseases. Second, changes might occur in the bureaucratic background to increase (or decrease) the tool's applicability. We have called this the phenomenon of convergent (or divergent) bureaucracy. Third, technical changes might allow for a better match between the actual degree of uncertainty and that permitted by the standard case. Computerization provides such an example.

In general, compromises are all that we have when we seek standard bureaucratic forms for dealing with heterogeneous groups of people and circumstances. Rather than seek to impose the one true way, we should become more aware of the properties inherent in these objects.

Despite a growing body of evidence from sociology and history of science, distributed artificial intelligence and distributed cognitive science, images of universal policy often involve the imposition of universal standardization schemes. We argue here that while such standards may emerge in physical systems or certain sorts of market conditions, for the class of phenomena described here no universal standard is possible. The number of actors, the different ways they structure information, the 'moving-target' nature of collecting scientific information over time when the science itself is changing: all these factors, and more, are true of most important classes of problems presenting themselves in the 'coordination theory' arena. It is often difficult to imagine building tools whose purpose is to collect precise, uniform, and complete information from a large domain over a long time – and invoke the concepts of ambiguity, fuzziness and plastic meanings for their design. The initial designers of the ICD certainly did not intentionally build such features into their data-collection system; on the contrary, they were devout positivists, bent on intellectual and moral recruitment to the truth. Yet as the capital 'T' Truth remained elusive, they did develop pragmatic workable compromises, many of which used those features.

Some guidelines emerge at this point:

1 In the face of incompatible information or data structures among users or among those specifying the system, attempts to create unitary knowledge categories are futile. Rather, parallel or multiple-representational forms are required. So, for example, instead of trying to represent a disorder of energy diagnosed with acupuncture as a nervous disease in western medical terms, a parallel representational scheme will avoid imposition of inappropriate categories.

2 Pragmatically, the 'Occam's razor' of the coding of information means that too few categories will result in information that's not useful ('alive' or 'dead', while having the virtues of simplicity and (near) exhaustiveness, don't tell us much about disease in the world), while too many categories will result in increased bias, or randomness, on the part of those filling out the form. An ICD with 5 million numbers may be more scientifically accurate, but most doctors would

not even look at such a death certificate. Thus, at the level of *encoding* tools need to be sensitive to the working conditions of those encoding the data.

3 Imposed standards will produce workarounds. Because imposed standards cannot account for every local contingency, users will tailor standardized forms, information systems, schedules, etc. to fit their needs. A good summary of this appeared recently on a feminist button proclaiming, 'One size does NOT fit all!' Gasser (1986) identified three major classes of such informal responses to imposed standards: *fitting, augmenting*, and *working around*. In terms of designing tools for distributed, organizational decision- and policy-making, a detailed catalogue and analysis of such responses could become part of the designers' toolkit; incorporated in the system, could point out styles of workarounds at the level of coding.

4 Identifying granularity of the problem, then encoding it in the system where appropriate, would complement existing organizational information processing. For example, in natural-history work, biologists are often classed as 'lumpers' vs 'splitters'. Lumpers tend to identify fewer species, lumping together specimens with fine-grain distinctions, and conversely with splitters. Such individual-level habits or tendencies have also been documented among those filling out certificates of death. At this level of individual encoding, it is possible to track decision-making and signal bias in one direction or another (and in fact such capacities exist in several domains, both computerized and manual). However, the monitoring of relatively simple habits and creating mnemonic tools to correct for them become impossible at the level of occupational specialties or large governmental bodies. Collective memories and practices have a different structure, and require much more complex representations. Thus, the rule of thumb for designers here would be to tailor the complexity of the representation around this issue of organizational scale.

5 Match the structure of the information system in the 'middle' of the different participants with the mismatch of their information needs. For example, in the case of the ICD, we have a repository maintained by one group of people, 'fed' by forms coming in from a widely distributed constituency. There is a good match between the types of information being collected (heterogeneous, non-matching information structures) and the repository; similarly between the use of forms and the far-flung, disparate encoders of information.

Another sort of object or system inserted in the middle of this process could be disastrous – an abstract analytical schema with tightly controlled coding requirements, for example, could severely hamper data-collection efforts.

CONCLUSION

The work in this area has just begun – with the advent of very large-scale information systems and technologies, and increasing concern with electronic integration, coding and coordination across geographically dispersed groups, the issues presented here become pressing. We see our contribution to this set of questions as analysing the ways human organizations historically have reached solutions to this class of problems with and without computing technology, and to reflect back into the technology and the business world the angle of vision of history and sociology. On a more practical level, we would like to define as precisely as possible the creation, maintenance, and perhaps destruction of decisions in information practices, especially inter-organizationally.

Sociology of science and technology have emphasized 'opening the black box' of technology, a kind of social 'reverse engineering' of the interests and rhetoric inscribed therein. Recent organizational and policy analysis has shown how these black boxes may be opened and closed as circumstances and structural conditions change and rhetorical resources are mobilized (see also Chapter 2). Yet here we have a hybrid of these conditions, where the box, if you will, is neither clearly closed nor black. Perhaps the oxymoronic 'open black box' (Star 1992) would be a fitting name for this phenomenon, deserving further and urgent investigation in its own right.

NOTES

1 We would like to acknowledge the help of our colleagues Joan Fujimura and Alberto Cambrosio, for many hours of stimulating discussion of the issues presented here. Part of this research was conducted with a Faculty Development Award from the University of California, Irvine. Annemarie Mol, Lisa Bud-Frierman and Anne Fagot-Largeault made extensive and very helpful comments on an earlier draft of this paper. We also acknowledge the helpful comments of several anonymous referees at the HICSS '91 conference. The Archives of the United Nations and of the World Health Organization, Geneva, kindly gave us access to unpublished material.

2 DRGs are used for medical accounting, and rely on rearrangements of medical classifications and procedures.

3 Two notable exceptions here are from philosophy and from sociology: philosopher Anne Fagot-Largeault's magisterial discussion of the ICD and its inscribed philosophy of causality (Fagot-Largeault 1989). She emphasizes causation rather than organization, but is fully aware that the two are complementary. The ICD's highly visible cousin, the Diagnostic and Statistical Manual (DSM) records psychiatric classifications. The categories encoded by the DSM are perhaps more accessible to traditional policy and social-movement analyses. An example here is its recent demedicalization of homosexuality, which reflected two decades of gay and lesbian activism and confrontation of the psychiatric establishment. The DSM has been the subject of numerous articles in social sciences; a good summary can be found in Kirk and Kutchins (1992).

4 The power of a classification of disease can be seen, for example in the debate about Britain's mortality decline in the nineteenth century (Szreter 1988). Three interest groups have at different times claimed the kudos here – and a share of funding and recognition appropriate to their contribution: medical specialists who claimed new forms of treatment rid the country of its major scourges (particularly TB); public-health officials who asserted the value of sanitation in the cities; *laissez-faire* economists who highlighted the general rise in the standard of living in a successful economy unburdened by expensive medical welfare. The stakes in the debate were clearly huge. As Simon Szreter has shown in his careful revisionist history, the outcome hinges on a reading of the Tables of Mortality which listed causes of death by region. These show unequivocally that the new forms of treatment developed after the decline in mortality (as McKeough had brilliantly demonstrated years ago, in the context of a debate about national medicine), but (*contra* McKeough, who underscored the rise in the standard of living) in step with local public-health measures. The core of Szreter's argument is an interpretation of disease classification in the nineteenth century (particularly the categories of airborne disease).

BIBLIOGRAPHY

Archival sources

Note: We have followed the form suggested for citation published by the Archives of the United Nations, Geneva; except where noted the references are taken from that archive.

CH/Experts Stat/34 2 December 1927 'Report of the Committee of the Vital Statistics Section of the American Public Health Association on the accuracy of certified causes of death and its relation to mortality statistics and the international list'.

CH/Experts Stat/43 20 December 1927 Dr P. I. Kurkin, 'Note sur la nomenclature des maladies et des causes de décès en Russie'.

CH/Experts Stat/78 Dr E. Roesle, 'The international recommendations for determining the causes of death drawn up by the Health Section of the League of Nations in 1925, and their applicability as regards the reform of the German statistics of causes of death'.

CH/Experts Stat/80 'Government Commission on Morbidity and Mortality Statistics in Austria, with reference to the 4th revision', 3.

CH/Experts Stat/87 'Registrar General' of England and Wales, 'Observations upon Dr Roesle's memorandum upon the comparative study of morbidity'.

CH/Experts Stat/88 Dr Teleky, 'La Statistique de morbidité des caisses d'assurance-maladie en Allemagne' 19 March 1929.

Commission Internationale Nomenclature Internationale des Maladies, *Procès verbaux*, 1910, Paris.

La Réunion du Conseil de la Société des Nations, Saint Sebastian et l'Organisation Internationale d'Hygiène Publique, 1923.

Société des Nations, Box R822, File 12458 Session of the OIHP (Paris 1921).

Société des Nations, Organisation d'Hygiène, Commission d'Experts Statisticiens, CH/Experts Stat/1–43, 1927, Communication du Chef de Service de la Statistique Médicale au Ministère Polonais de l'Intérieure.

WHO Archives, 453–1–4, E. J. Pampana, 'Malaria as a problem for the WHO'.

WHO Archives, 455–3–3, Collaborating with International Institute of Statistics, 29/1/47, Huber.

WHO Archives, 455–3–4, 31/3/48, Expert Committee for the Preparation of the 6th Decennial Revision of the International List of Diseases and Causes of Death, 'Assignment of causes of death'.

References

Bertillon, J. (1887) *Rapport sur les travaux de l'Institut de Statistique (Session de Rome, avril 1887) et sur l'organisation de la direction générale de statistique en Italie*, Paris: Société d'Editions Scientifiques.

—— (1906) *De la fréquence des principales causes de décès à Paris pendant la seconde moitié du XIXème siècle et notamment pendant la période 1886–1905*, Paris: Société d'Editions Scientifiques.

Bijker, W. and Law, J. (1992) 'General introduction', in W. Bijker and J. Law (eds), *Shaping Technology/Building Society: Studies in Sociotechnical Change*, Cambridge, MA: MIT Press.

Bitner, E. and Garfinkel, H. (1967) 'Good organizational reasons for bad organizational records', in H. Garfinkel (ed.), *Studies in Ethnomethodology*, Englewood Cliffs, NJ: Prentice Hall.

Bloor, M. (1989) 'A minor office: the variable practice of death certification', paper presented to the British Sociological Association, University of Glasgow.

Boltanski, L. and Thévenot, L. (1987) *Les Economies de la grandeur*, Paris: PUF, Cahiers du Centre d'Etudes de l'Emploi.

—— (1991) *De la justification des économies de la grandeur*, Paris: Gallimard.

Cicourel, A. (1964) *Method and Measurement in Sociology*, New York: Free Press of Glencoe.

Desrosières, A. (1988) *Les Catégories socio-professionnelles*, Paris: La Découverte.

Dodier, N. (1990) 'How are medical judgements transcribed? Occupational physicians and administrative protocols', paper given to the colloquium 'The Social Construction of Health', Bielefeld, Germany.

Ewald, F. (1986) *L'Etat providence*, Paris: Grasset.

Fagot-Largeault, A. (1989) *Les causes de la mort: Histoire naturelle et facteurs de risque*, Paris: Urin.

Foucault, M. (1970) *The Order of Things: An Archaeology of the Human Sciences*, London: Tavistock Publications.

Fujimura, J. (1987) 'Constructing "do-able" problems in cancer research: articulating alignment', *Social Studies of Science* 17: 257–93.

Gasser, L. (1986) 'The integration of computing and routine work', *ACM Transactions on Office Information Systems* 4: 205–25.

Geist, P. and Hardesty, M. (1992) *Negotiating the Crisis: DRGs and the Transition of Hospitals*. Hillsdale, NJ: Lawrence Erlbaum.

Goody, J. (1971) *The Domestication of the Savage Mind*, Cambridge: Cambridge University Press.

—— (1987) *The Interface Between the Written and the Oral*, Cambridge: Cambridge University Press.

Hewitt, C. (1985) 'The challenge of open systems', *BYTE* 10: 223-42.

—— (1986) 'Offices are open systems', *ACM Transactions on Office Information Systems* 4: 271–87.

Hughes, T. P. (1987) 'The evolution of large technological systems', in W. E. Bijker, T. P. Hughes and T. J. Pinch (eds), *The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology*, Cambridge, MA: MIT Press.

King, J. and Star, S. L. (1990) 'Conceptual foundations for the development of organizational decision support systems', *Proceedings of the 23rd Hawaiian International Conference on Systems Sciences*, vol. 3, Washington, DC: IEEE Press, pp. 143–51; revised version in *Organization Science*, forthcoming.

Kirk, S. A. and Kutchins, H. (1992) *The Selling of DSM: The Rhetoric of Science in Psychiatry*, Hawthorne, NY: Aldine de Gruyter.

Kraemer, K., Dickhoven, S., Tierney, S. F. and King, J. L. (1987) *Datawars: The Politics of Modeling in Federal Policymaking*, New York: Columbia University Press.

Latour, B. (1987) *Science in Action*, Milton Keynes: Open University Press.

Morgan, G. (1986) *Images of Organization*, Beverly Hills, CA: SAGE.

Pinsonneault, A. and Kraemer, K. L. (1989) 'The impact of technological support on groups: an assessment of the empirical research', *Decision Support Systems* 5: 197–216.

Roth, J. (1966) 'Hired hand research', *American Sociologist* 1: 190–6.

Serres, M. (1983) *Le Passage du Nord-Ouest*, Paris: PUF.

Star, S. L. (1989a) 'The structure of ill-structured solutions: heterogeneous problem-solving, boundary objects and distributed artificial intelligence', in M. Huhns and L. Gasser (eds), *Distributed Artificial Intelligence 2*, Menlo Park, CA: Morgan Kauffmann.

—— (1989b) *Regions of the Mind: Brain Research and the Quest for Scientific Certainty*, Stanford: Stanford University Press.

—— (1989c) 'Layered space, formal representations and long-distance control: the politics of information', *Fundamenta Scientiae* 10: 125–55.

—— (1991) 'Power, technologies and the phenomenology of standards: on being allergic to onions', in John Law (ed.), *A Sociology of Monsters?*

Power, Technology and the Modern World, Sociological Review Monograph, No. 38. Oxford: Blackwell.

—— (1992) 'The Trojan door: organizations, work, and the "open black box"', *Systems/Practice* 5: 395–410.

Star, S. L. and Griesemer, J. (1989) 'Institutional ecology, "translations," and coherence: amateurs and professionals in Berkeley's Museum of Vertebrate Zoology, 1907–1939', *Social Studies of Science* 19: 387–420.

Szreter, S. (1988) 'The importance of social intervention in Britain's mortality decline c. 1850–1914: a re-interpretation of the role of public health', *Social History of Medicine*: 1–37.

Tort, P. (1989) *La Raison classificatoire: Quinze études*, Paris: Aubier.

Yates, J. and Orlikowski, W. J. (1992), 'Genres of organizational communication: a structurational approach to studying communication and media', *Academy of Management Review* 17: 299–326.

~~224~~

214-216
N/A

Part III

Knowledge and business

10 Information, power and the view from nowhere

Theodore M. Porter

Every human activity – child-rearing, hunting, farming and crafts, no less than administration, research and government – depends on the use and transmission of skills and knowledge. The word 'information' might be, and sometimes is, used indiscriminately to designate all of this. Often, though, the term is restricted to the domain of the factual. Facts involve a very special kind of knowing. Tips, suspicions, informal gossip and bald assertions are no more factual than are unarticulated skills. The effective operation of a business depends crucially on all of these, but they are handled rather differently from, say, printed tables or spread sheets. Information, as used here, refers to something less personal and more explicit. Its validity must normally be certified by certain methods, agencies or persons whose credibility is widely acknowledged.

In a modern economy, especially, information means communication with people who are often unknown to one another, and who thus have little or no personal basis for mutual understanding. It depends, for that reason, on a shared discipline specifying the ways that it is generated and the ways it can be interpreted. The creation and use of information needs to be understood first of all as a problem of space and of scale, of getting beyond what is local, personal or intimate and creating knowledge that is, so far as possible, neutral and well standardized (see Chapter 11). The ideal, in short, is to go beyond perspective, to turn a view from somewhere into a 'view from nowhere' (Nagel 1986). Businesses and governments, as organizations spreading over large territories, depend on this. So also do scientists, and for identical reasons.

MAKING SCIENTIFIC NETWORKS

Science, in the western tradition, long meant logical or mathematical demonstration. This was not quite an absolute solution to the

problem of space, but it greatly mitigated it. The rules of formal logic and of geometry are strict and precise. Their validity depends only in the most general way, if at all, on what actually happens in the world of nature and artifice. This does not mean that universal agreement came automatically. Even in pure mathematics and theoretical physics, important differences of method and of intellectual and practical commitments have separated individuals, schools, and nations (see for example Smith and Wise 1989, pt 2, on physics and mathematics in the nineteenth century). But in deductive theory the problem of replication is generally no problem at all. Demonstration and proof, ideally, place no demands on personal trust. What matters most can be inscribed on paper and conveyed by messenger.

Experimentation, which developed much later in science, presents a much thornier problem from this perspective. In the rhetoric of science, experimentation has since the late seventeenth century been treated as the solid bedrock of knowledge, the vehicle through which nature itself rather than fallible and prejudiced humans can dictate the content of our knowledge. But nature does not speak unaided. Experimenters recognize the crucial element of skill that goes into the work, and this insight has been affirmed by a host of recent social studies of science. A similar argument applies to technological achievement, and hence to the economic development of regions and nations (Landes 1992). This work suggests that the element of skill is often so crucial, and so difficult to convey in words, that the transmission of instruments or techniques from one site to another is almost impossible. Impossible, that is, using information alone; a long visit and much practice – a kind of apprenticeship – will more likely enable the student or entrepreneur to gain sufficient mastery of a set of laboratory or industrial practices to recreate them at another site.

The idea that experimental work depends heavily on skill and private knowledge was emphasized by Michael Polanyi (1958) and Jerome Ravetz (1971). Harry Collins (1985) and other recent sociologists have reinforced and broadened this argument using laboratory field studies. Collins suggests that true replication is rare in the extreme. A piece of equipment or a laboratory operation can be reproduced only where there is extensive personal contact, and hence where all claims to independent confirmation have been abandoned. This is not so much replication as calibration. The whole process should perhaps be described in terms of the spread of human skills rather than the discovery of natural laws. The cyclotrons developed by Ernest Lawrence at Berkeley are typical. Anyone who

wanted to build a cyclotron in the 1930s was well advised to send someone to learn the trade at Lawrence's laboratory. Otherwise, Lawrence warned, they would never get one to work in a reasonable time. 'It is rather ticklish in operation, and a certain amount of experience is necessary to get it to work properly' (quoted in Heilbron and Seidel 1989: 318). Information, in a sense, is lacking, because the written word is powerless until reinforced by personal experience.

The problem of separating experimental knowledge from local craft skill was very possibly the greatest obstacle to its development as an acceptable constituent of science. As Steven Shapin and Simon Schaffer (1985) show, Thomas Hobbes argued effectively, though in the end fruitlessly, against experimental natural philosophy on just these grounds. Hobbes was as much an absolutist in science as in politics, because he recognized that knowledge is made within a polity, and that natural knowledge can have consequences for the larger political order. He issued both general and highly particular arguments against what he saw as the delusions of Robert Boyle, whose air pump was one of the first and most important experimental instruments. The detailed criticisms ultimately supported the general point, which was that experimentation can never provide an adequate basis for public knowledge. Reports prove nothing; witnesses must always be few, and can readily be deluded or coopted; the passage from observation to truth claims depends on personal interpretation. He might have added that the whole history of air pumps to date testified to the extraordinary difficulty of replication. Even the best ones were out of operation most of the time, and could not produce the paradigmatic results associated with creation of a vacuum. Experiment can never compel assent, can never make public knowledge, as geometrical demonstration readily can. Hence, Hobbes held, only the latter is a suitable basis for knowledge in the commonwealth.

How then can science claim general validity? Part of the answer lies in networks of researchers, who through extensive personal contact have acquired techniques and built and calibrated instruments to produce compatible readings. If direct contact is the main agency of the diffusion of experimental work, then science remains personal knowledge. Rather like the crafts in old-regime Europe, it is shared mainly through a system of apprenticeships and *Wanderjahre*. But of course this can't be the whole story. Often what begins as a technique demanding the most exquisite skills will in a few decades become reproducible in every student laboratory. This

is in large measure the result of improved instrumentation and unified standards. The experimental replication of results and processes is made vastly easier when the equipment becomes sufficiently standardized that it can be bought from a catalogue. Standard measurement units, often imposed by governments in collaboration with scientists, bring similar advantages. Techniques that once required the utmost skill may now be fully mechanized, so that any person brought up in a modern education system, linked to a reliable power grid, and with access to customary tools, reagents and other supplies can readily perform a chemical analysis or measure a physical constant in the comfort of his or her home, office, laboratory or factory. This is still a network, but one that no longer depends on personal travel by horse and buggy for its expansion.

The spread of standard instruments, machines and measurement devices is always necessary to make possible the effective use of information in experimental science. Here we have knowledge, though it pertains primarily to a world that has already been tamed through human intervention. This does not imply the incapacity of experimental research to say anything about the world outside the networks of intervention. But experiment has a life of its own (Hacking 1983), and that life is oriented almost entirely around an artificial world of fancy equipment, purified reagents, manufactured substances, and patented, genetically engineered life forms. It is only within this world that experimental reports can be put to work, much less replicated (Latour 1987).

This brief consideration of increasing experimental control still falls short of identifying the preconditions of information. Making knowledge, after all, involves people as well as instruments. And the involvement of people necessarily brings in the crucial ingredient of trust. As with the problem of constructing instruments, a small-scale personal solution is possible. The members of sub-disciplines may well have worked together, and will most likely have met at scientific meetings. In almost every case, it will be possible to know a good deal based on personal contact about a researcher's skill and reliability. Where such intimate knowledge is required, though, we have not yet fully entered the impersonal world of information. Other ways of gaining trust become all the more crucial if knowledge is to travel beyond the boundaries of local or disciplinary communities.

The technologies of large-scale trust are legion, and cannot be systematically surveyed here. Some remain rather personal and idiosyncratic. Robert Boyle aimed to win credence for his

experimental reports, in part, by reporting his work in excruciating detail, and telling his readers about experiments that failed as well as those that succeeded. His aim, as Shapin (1984) argues, was to produce the effect of virtual witnessing, and through disarming candour to convince readers of his own trustworthiness. The usual strategy for inspiring trust in science, as in business and government, is to cultivate the appearance of impersonality, or objectivity. This can be advanced by writing in the impersonal passive voice, by loading a text down with factual material and references, and by explicating choices using the language of statistical inference or decision theory rather than personal judgement. Also, one can ground personal authority in social authority by working in a known and respected organization, by advertising degrees or professional memberships, or by publishing in refereed journals. All these are especially important for making results credible to people outside the specialized community of experimenters, to people who are concerned less with the prospects for replication than with the grounds for belief.

THE WORLD MADE SAFE FOR BUREAUCRACY

A world of information, in short, is a world of standardized objects and neutralized subjects. It is knowledge detached from local sites, where skill and an intimate familiarity with people and things provide the most promising route to success. Science has played a considerable role in making this world, but the community of investigators of nature is in no simple way the prototype of the information society. It is perhaps more helpful to say that the political and administrative situation within which information became powerful formed the context also for the development of modern science (Porter 1992b).

The creation of business information, no less than experimental work in physics or chemistry, depends on standardization and on a kind of calibration, which if anything is even more demanding in the social field than in the natural. This has been demonstrated with exceptional clarity for the case of statistical information about populations. To be of utility, national statistics required the creation of measures and categories of people that were commensurable over the whole country. The degree of bureaucratic intervention required was so great that it was nearly impossible to create standard categories for international statistics (Brian 1989). Even the institutionalization of a uniform international classification of disease has proved extraordinarily difficult, mainly because this depends on a

uniform, well-disciplined workforce (see Chapter 9). The first great statistical efforts undertaken in the wake of the French Revolution ran up against the intractable diversity of regions and measures, and were largely a failure (Bourguet 1989).

It is not quite right to say that there could be no quantitative information before the heavy hand of the state imposed uniformity on a variegated landscape. For one, the state was not alone in promoting more uniform categories and measures. The construction of extensive trading networks created a pressure for a simplification and standardization of measures. Even more significant was the growth of large firms (see Chapter 2). The Railway Clearing House (see Chapter 3) is a marvellous example of an artificial domain of quantification created by companies to settle their financial affairs. Science also provided an array of tools and incentives for making fixed, uniform measures. Experimental results could scarcely have claimed general validity except with the benefit of widely shared measurement systems and the skilled manufacture of instruments. Both science and business, however, have worked often as allies of the centralizing state, especially in the last two centuries, and each is broadly consistent with a story of quantification made possible through some transformation of the objects and processes to be quantified.

This identification of numbers with administration and artifice invites also a second objection: that quantities played an important role in social and economic life long before the arrival of rationalistic social scientists, professional business managers, and Weberian bureaucrats. Economic exchange is almost inconceivable except on the basis of quantity, a conception already pervasive in ancient times. The standard western iconography of justice derives from a sense of the special fairness of measures, as Witold Kula (1986) points out. The Jewish God spoke very often in numbers, though we have no evidence that Moses was sent down from Mt Sinai with a platinum cubit to place beside the ark of the covenant. Thus even the divine specifications for the temple did not exclude personal interpretation. And up to the end of the eighteenth century, in Europe, measurements and prices almost always left considerable room for judgement and negotiation. Haggling is the rule of the market-place. For some crucial commodities, such as grain, the doctrine of just price was enshrined by custom. In that case, as Kula shows, negotiation would take place over the size of the heap on the bushel vessel, which would depend on the quality of the grain and on the relative legal and economic conditions of the bargainers. Musty wheat or oats would

naturally be sold in larger bushels than good quality wheat, and a noble seigneur or merchant would enjoy certain privileges over a mere peasant.

We must also consider the diversity of measures and prices. Where transportation was difficult, no commodity could have a single price over a considerable territory. And given the bewildering variety of units of measurement, it would have been hard to know if one did. Every village in eighteenth-century France had its own bushel measure, and often its own measures of land, weight and liquid volume. In many cases there would be variant units depending on the substance measured. The burden of memorization and calculation was thus formidable, even within a single system, and the problem of translation was such as to require masters of reckoning to manage the arithmetic. As John Heilbron remarks:

> Calculation of the price of a piece of cloth 2 yards 1 foot 4 inches square at 3 pence 2 farthings the square foot was a sufficient challenge. To change it into aunes, pieds, livres, and deniers, and to proceed to a problem in bushels and king's feet, would have puzzled Archimedes.
>
> (Heilbron 1990: 212; see also Cohen 1982)

Such conditions provided myriad opportunities to earn profits for a merchant with good local informants, buying in one market and selling in another. But what he might learn from them could only be called information in the loosest sense of the term. Here there were few facts that could be separated from the context of their production, and used by people far away. Large-scale trading operations were possible only through a system of trusted agents, on the scene (on commerce and information in the eighteenth century, see Brown 1989, ch. 5). It was scarcely even possible to know what prices meant before there was a centralized system of weights and measures. Although the English had gone farthest in this direction in the eighteenth century, the landmark event in the standardization of measures was the imposition of the metric system in France and its conquered territories in the time of its great revolution. Significantly, this involved a close collaboration with leading scientists.

Uniform weights and measures still did not suffice to give the advantage to information over direct sensory experience in dealing with agricultural production. The development of the grain trade in Chicago, recently described by William Cronon (1991, ch. 3) provides a nice continuation to these remarks on the history of measures. The American Midwest was the rationalistic administrator's

dream, since this flat country was plotted out in squares before white settlers arrived in any numbers. But as Cronon observes, the produce of each farm long maintained its ineffable uniqueness. The Chicago Board of Trade, founded in 1848 as a voluntary organization of businessmen, began almost immediately a campaign to impose some uniformity on this highly variegated world. It did so in the interest of business efficiency, and to provide safeguards against fraud. This push for standards cannot be viewed as a spontaneous development in the market-place; the Board of Trade was, almost from the beginning, quasi-governmental. Its members recognized the problem Casson describes (see Chapter 7): high information (and storage) costs, if every farmer's grain was to be kept separate, and an insufficient basis for personal trust. They aimed to solve it by creating uniform standards. This meant, in the first instance, replacement of the old bushel sack in which grain was shipped down rivers with a bushel measure defined as a given weight. This latter was better suited to the new grain elevators. Unfortunately the Board was not powerful enough to enforce a choice between the 56- and the 60-pound bushel, each of which persisted for decades. But this was a modest problem in comparison with one the Board took on beginning in 1856, which was to set standards of quality for wheat. Fixed, homogeneous categories would relieve elevator operators of the obligation to keep each farmer's grain in a separate compartment. Initially there were no formal standards; the individual elevator operators were left to decide what was acceptable wheat. But when farmers discovered that they would receive approximately the same price for excellent clean wheat as for dirty, damp or sprouted wheat, they began complaining bitterly. They also began mixing their wheat with dirt and chaff, or at least taking little care to clean it. Soon the price of Chicago wheat in New York fell 5 to 8 cents below that of Milwaukee. This price differential was itself a tribute to the growing power of information in a new era of international agricultural trading.

But that was no consolation to Illinois farmers, nor to Chicago merchants, who rapidly began losing business in favour of Milwaukee. Clearly the cost of this system was too high. The Board of Trade began in 1857 to subdivide its wheat into grades based on quality. It also appointed a city grain inspector, to keep watch over the grading operations at the various elevators. Such casual inspection proved insufficient, and in 1860 the chief inspector was ordered to train his own assistants. For a set fee, these inspectors would certify the grade of any shipment of grain to be traded on the Chicago Exchange. To do this they had to be given the right to enter the elevators and

inspect the grain personally. But even this was not enough. There were only four grades of spring wheat, and elevator operators soon learned that by strategically mixing wheat of different grades they could produce a larger lot of wheat that would still fall in the higher grade, and command a higher price. Farmers considered that these illicit profits came directly from their own pockets, and complained bitterly to newspapers and elected officials. Controlling the politics was as crucial as grading the wheat for the standardization of grain, and the Board of Trade joined the farmers in support of laws against mixing wheat of different grades.

In the end, bureaucrats and traders managed to create what had never existed in nature: uniform categories of natural produce. Thereafter, wheat – indeed, wheat futures – could be bought and sold on the Chicago Exchange by traders who had never seen it and never would; who wouldn't have been able to distinguish rejected red winter wheat from club-class spring wheat. This net of regulatory activity created a space for information, in the modern sense. In 1845, a successful trader in wheat was somebody who spent his time at farms, ports and rail terminals, running his fingers through individual shipments and deciding its value. Two decades later the knowledge needed to trade wheat had been separated from the wheat and the chaff alike. It now consisted of information, such as price data and production data, which were to be found in printed documents and on the floor of the Exchange.

OBJECTIVITY AND ACCOUNTS

Accounting as we know it results from an even more formidable achievement. Accounts translate diverse human activities into financial terms. But we cannot suppose that expression in numbers alone is sufficient to create information. For, as with experimental science, information presupposes a degree of neutrality or objectivity. The numbers must not be opaque to those who lack an intimate understanding of the affairs they summarize. They must be capable of going out into the world alone and of guiding human actions in widely scattered places. It must be possible to assign them meanings or put them to work following shared routines.

In practice, this normally means that the generation of these numbers should be as impersonal as possible. The measure of return on equity or book value should not depend too much on who prepared the accounts. This is especially true because of the vital public function they perform. Measures of profitability, sales, expenses,

receipts and book value fill the reports that must be made available to stockholders. They provide the basis for calculating tax obligations, and for determining if an organization remains solvent. Because the categories are often specified by law, they cannot simply be left to private judgement. Discretion and self-interest run together, and self-interest may favour a form of calculation that in essential ways is misleading or unfair. To avoid this requires that the rules of calculation be specified in considerable detail, and indeed that a constant stream of regulations be propagated in response to evolving strategies and loopholes discovered by firms and accountants. Governments, clearly, have been the leading purveyors of rules specifying the proper ways of calculating and presenting accounts. Accounting standards boards have joined in, often to forestall the regulatory authorities. But these public bodies are not alone, and any use of accounts to manage the affairs of large, especially multi-divisional, organizations presupposes some centrally dictated form of quantitative control.

Thus is accounting information created. There remains some doubt about its adequacy as a basis for action. Accountants and other quantitative professionals have often resisted this proliferation of rules, on the grounds that they will almost always be too crude to take proper account of subtle differences. They have argued, with modest success, that a self-governing profession provides a better basis for financial knowledge than proliferating rules ever can. In some cases, such as an 1853 inquiry into life insurance by a select committee of the House of Commons, the split between government advocacy of mechanical objectivity and the professional defence of expertise and judgement could be quite stark (Porter forthcoming). This inquiry was inspired by the fear that many of the new life insurance companies were spending far too much on salaries and promotion, or charging insufficient rates. If true, the inevitable effect would be insolvency twenty or thirty years later, when the insured began dying in large numbers. Members of the select committee hoped that the application of rigorous actuarial tables and accounting standards in published reports would permit potential customers to learn for themselves whether a company was sound, and thus protect the public interest without requiring detailed regulation and meddling. The actuaries responded by explaining that theirs was an intricate craft, dependent on shrewd investment and an ability to separate good lives from bad ones. The solvency of the companies was to be guaranteed not by public information, but by the skill and integrity of the actuaries themselves. The drive to make public

information out of insurance records was thus led neither by the companies nor by quantitative professionals, but by government regulators (Select Committee on Assurance 1852–3).

The history of accounting, likewise, suggests that the pursuit of strict and impersonal financial standards derives more from government interference, and from accounting conventions imposed to forestall government involvement, than from any pursuit of financial truth on the part of firms and experts. It is necessary to add that, in accounting as in statistics, the numbers have taken on a life of their own, and in some ways even helped to form a new corporate culture. Academic researchers in accounting, inspired by a somewhat doubtful model of proper scientific practice, have been inclined to put faith in objective knowledge over loosely constrained judgement. Business schools have been at least partly successful in inculcating their students with this new ethic of managing by the numbers.

That ethic has not won universal applause. A recent historical study of management accounting blames it in part for the poor performance of American business. This does not quite amount to an attack on quantification. Skilful use of appropriate numbers by people who are close to the operations they summarize is entirely laudable, they argue. But those who regard the numbers as detached information, a sufficient basis in themselves for managerial decisions, are likely to miss what is most crucial. This is all the more dangerous because the numbers themselves are collected mainly to comport with externally imposed standards for financial reporting, and not to provide maximally useful information for business decisions (Johnson and Kaplan 1987). The austere presentation of numbers mandated by government was opposed by elite American accountants in the 1930s and 1940s, and more recently has been criticized for its excess of positivism in the name of rhetoric and interpretation (Lavoie 1987). Many proponents of accountancy agree with the critics that to interpret the numbers adequately requires skill and insight going beyond or behind them.

Such skill and insight have by no means disappeared, and any balanced treatment of information would have to show how they are acquired and put to use. For present purposes, though, it is more important to note that a respect for surfaces also has its advocates. The classic strategy for using accounts in the management of multi-divisional organizations, defended by Donaldson Brown and Alfred Sloan of General Motors, calls for the top level of management to judge divisions mainly by a single composite number, return on investment. Their purpose was to combine 'centralized control with

decentralized responsibility' (Brown 1927). Peter Miller and Ted O'Leary (1987) observe that this is a strategy designed to preserve discretion at the middle levels of management. If they can be confident that their superiors will not be examining their decisions too closely, divisional managers and their subordinates can follow hunches and intuitions without a need for detailed justification. At the same time, they know that their insulation is only partial and that in the end they will be judged by their profitability numbers. Especially if those numbers are credible, they may also judge themselves by this standard. Objective numbers thus provide a gentle but powerful means of control, an agency for harnessing individual creativity and constructing 'governable persons'.

Regulatory authorities have even more incentive than top managers to define numbers that are adequate in themselves to judge the legality and propriety of a set of practices. The alternative is to inquire and intervene in the most minute details, which sometimes becomes necessary but is generally regarded on both sides as undesirable in a capitalist economy. Perhaps the most important reason for the pursuit of autonomous information is political. When everything essential can be expressed in a few simple numbers, democratic self-reliance is greatly promoted. It is inconceivable that a large, diverse, and widely scattered population can develop a refined intuition about the affairs of government and business. But if information is self-sufficient, obviating all need to probe behind surfaces, such individuals can reach decisions about investments, purchases, contracts, and even voting with a minimum of paternalistic interference. Autonomous information, if it is not too complex, can be genuinely public knowledge. It has a decidedly democratic resonance (Ezrahi 1990; Porter 1992a). This renunciation of depth – the belief that one can effectively use numbers without looking behind them – is doubtless in large part an illusion. But not entirely. In a world that respects information, information becomes powerful. Numbers, even misleading ones, can take on a life of their own. The recent history of reporting by official statistical agencies makes this very plain (Alonso and Starr 1987; Desrosières 1990; also Hacking 1990).

We might reasonably suppose that those who know their way around in elite society will never be mainly dependent on information in its public, objectified sense. And it is indeed true that elites, almost by definition, have access to knowledge that is not available to the general public. But where economies and governments function on a global scale, local knowledge deriving from face-to-fact interactions will almost inevitably be inadequate (Beniger 1986). Knowledge,

detached from the skills and close acquaintanceships that flourish in local sites, becomes information. The history of information is almost synonymous with the history of large enterprises (Yates 1989). It is perhaps possible to administer such enterprises relying exclusively on a system of trusted deputies, but in practice almost everyone in an interdependent world will need to rely often on public information. Where a hierarchical system of deputies is impossible, and especially where democratic values demand public accountability, information becomes all the more indispensable. Thus we find government and business pressed by problems quite similar to those encountered in science as experimenters worked to make knowledge that could be readily transported from laboratory to laboratory, and hence claim universal validity.

BIBLIOGRAPHY

Alonso, W. and Starr, P. (eds) (1987) *The Politics of Numbers*, New York: Russell Sage Foundation.

Beniger, J. (1986) *The Control Revolution: Technological and Economic Origins of the Information Society*, Cambridge: Harvard University Press.

Bourguet, M. N. (1989) *Déchiffrer la France: la statistique départementale à l'Epoque Napoléonienne*, Paris: Editions des Archives Contemporains.

Brian, E. (1989) 'Statistique administrative et internationalisme statistique pendant la seconde moitié du XIXe siècle', *Histoire et Mesure* 4: 201–24.

Brown, D. (1927) *Centralized Control with Decentralized Responsibility*, New York: American Management Association.

Brown, R. (1989) *Knowledge is Power: The Diffusion of Information in Early America*, New York: Oxford University Press.

Cohen, P. (1982) *A Calculating People: The Spread of Numeracy in Early America*, Chicago: University of Chicago Press.

Collins, H. (1985) *Changing Order*, Los Angeles: Sage.

Cronon, W. (1991) *Nature's Metropolis: Chicago and the Great West*, New York: Norton.

Desrosières, A. (1990) 'How to make things which hold together: social science, statistics and the state', in P. Wagner, B. Wittrock and R. Whitley (eds), *Discourses on Society: The Shaping of the Social Science Disciplines, Sociology of the Sciences: A Yearbook*, Dordrecht, Boston and London: Kluwer Academic Publishers.

Duncan, O. (1984) *Notes on Social Measurement: Historical and Critical*, New York: Russell Sage Foundation.

Ezrahi, Y. (1990) *The Descent of Icarus: Science and the Transformation of Contemporary Democracy*, Cambridge: Harvard University Press.

Hacking, I. (1983) *Representing and Intervening*, Cambridge: Cambridge University Press.

—— (1990) *The Taming of Chance*, Cambridge: Cambridge University Press.

Heilbron, J. (1990) 'The measure of enlightenment' in T. Frängsmyr,

J. Heilbron and R. Rider (eds), *The Quantifying Spirit in the Enlightenment*, Berkeley: University of California Press.

Heilbron, J. and Seidel, R. (1989) *Lawrence and his Laboratory*, Berkeley: University of California Press.

Johnson, H. T. and Kaplan, R. (1987) *Relevance Lost: The Rise and Fall of Management Accounting*, Boston: Harvard Business School.

Kula, W. (1986) *Measures and Men*, trans. Richard Szreter, Princeton: Princeton University Press.

Landes, D. (1992) 'Homo faber, homo sapiens: knowledge, technology, growth, and development', *Contention* 1,3: 81–107.

Latour, B. (1987) *Science in Action*, Cambridge: Harvard University Press.

Lavoie, D. (1987) 'The accounting of interpretation and the interpretation of accounts', *Accounting, Organizations and Society* 12: 579–604.

Miller, P. and O'Leary, T. (1987) 'Accounting and the construction of the governable person,' *Accounting, Organizations and Society* 12: 235–65.

Nagel, T. (1986) *The View from Nowhere*, New York: Oxford University Press.

Polanyi, M. (1958) *Personal Knowledge*, Chicago: University of Chicago Press.

Porter, T. (1992a) 'Objectivity as standardization: the rhetoric of impersonality in measurement, statistics, and cost-benefit analysis', *Annals of Scholarship* 9: 19–59.

—— (1992b) 'Quantification and the accounting ideal in science' *Social Studies of Science* 22: 633–51.

—— (forthcoming) 'Precision and trust: early Victorian insurance and the politics of calculation,' in M. Norton Wise (ed.), *The Values of Precision*, Princeton: Princeton University Press.

Ravetz, J. R. (1971) *Scientific Knowledge and its Social Problems*, New York: Oxford University Press.

Select Committee on Assurance Associations (1852–3) *Report, British Parliamentary Papers*, XXI.

Shapin, S. (1984) 'Pump and circumstance: Robert Boyle's literary technology', *Social Studies of Science* 14: 481–520.

Shapin, S. and Schaffer, S. (1985) *Leviathan and the Air Pump: Hobbes, Boyle and the Experimental Life*, Princeton: Princeton University Press.

Smith, C. and Wise, N. (1989) *Energy and Empire: A Biographical Study of Lord Kelvin*, Cambridge: Cambridge University Press.

Yates, J. (1989) *Control through Communications: The Rise of System in American Management*, Baltimore: Johns Hopkins University Press.

2 31- 47

11 Information mythology

The world of/as information

Geoffrey Bowker

D83
L86

INTRODUCTION

From one vantage point, the 'information revolution' seems to be a highly prosaic affair involved with the growth of computers and their associated bureaucratic structures. However, writers who use this argument frequently deploy another, wherein it seems to be a revolution dense with meaning – one that will unlock the secrets of life and the universe. Beniger's *The Control Revolution* is a prime example of this double trend. On the one hand Beniger writes that:

> The rapid development of rationalization and bureaucracy in the middle and late nineteenth century led to a succession of dramatic new information-processing and communication technologies. These innovations served to contain the control crisis of industrial society in what can be treated as three distinct areas of economic activity: production, distribution, and consumption of goods and services.
>
> (Beniger 1986: 16)

Here we have a window on the world of Shannon files, press-books, stencils and memoranda so carefully detailed by Yates (1989). Yet this mundane universe is redolent with meaning. Thus Beniger asks: 'Why has information – of all commodities – come to dominate the economies of at least a half-dozen advanced industrial nations?'; and answers his own query as follows:

> Ultimate answers to these questions, we have found, lie at the heart of physical existence. In order to oppose entropy and put off for a time the inevitable heat death, every living system must maintain its organization by processing matter and energy. Information processing and programmed decision are the means by which

> such material processing is controlled in living systems, from macromolecules of DNA to the global economy.
>
> (Beniger 1986: 58–9)

Beniger is not alone. Herbert Simon tells us within the space of a single paragraph that

> From an economic standpoint, the modern computer is simply the most recent of a long line of new technologies that increase productivity and cause a gradual shift from manufacturing to service employment. . . . Perhaps the greatest significance of the computer lies in its impact on Man's view of himself. No longer accepting the geocentric view of the universe, he now begins to learn that mind, too, is a phenomenon of nature, explainable in terms of simple mechanisms.
>
> (Forester 1980: 434)

This last point, echoing Norbert Wiener's sketch of the history of science (humanity being no longer spatially then temporally then intellectually central) places the information revolution on an eschatological base at the same time as the first point puts it on an economic base (Wiener 1948). For a last example, the *Oxford Dictionary of Computing* ranges widely in two consecutive sentences:

> In principle any conceivable material structure or energy flow could be used to carry information. The scale of our use of information is one of the most important distinctions between the human species and all others, and the importance of information as an economic commodity is one of the most important characteristics of the 'post-industrial' civilization, which we are often said now to be entering.
>
> (*Oxford Dictionary of Computing* 1983: 182)

From the nature of the universe to the nature of humanity to the organization of the economy in three easy steps.

Perhaps the most surprising thing about these conjunctions is that they do not surprise. We are used to the mythological dimension of the information revolution.[1] Business history regularly gets articulated with the meaning of life in a non-problematic way. One possible treatment of this articulation is to dismiss it as hyperbole. For its detractors, this is the simplest and perhaps the most common treatment (for an example, see the mordant denunciation of the 'computer revolution' in Kling 1991); yet it is also one which denies the complexity of this historical phenomenon. I shall argue here that

there is a compelling connection between the information revolution as an economic fact and as a statement about the nature of the universe. In particular, I shall argue that this 'information mythology' stems from a set of work practices whose constitution illustrates an important dimension of the relationship between information, knowledge and society.

SPACE, TIME AND INFORMATION

In the story that we are looking at, 'information' can travel anywhere and be made up of anything. Sequences in a gene, energy levels in an atom, zeros and ones in a machine and signals from a satellite are all 'information' and are thus subject to the same laws. If everything is information, then a general statement about the nature of information is a general statement about the nature of the universe.

In this chapter, I will highlight the work that is involved in making this story true. I shall look in detail at two case studies; the first deals with the narrative construction of this story about information and the second is concerned with its practical construction. In both cases, I will stress the relationship between the existence of new work practices and the successful telling of the story – and thus indicate why it is possible for the sublime and the mundane to coexist in accounts of the information revolution. I shall argue that there is a simple sociological chain that links the world of business and the world of knowledge, with that chain's links being information management and organizational structure. Here I will give an historical and historiographical introduction to these case studies.

It is clear that both scientists and others have only a limited set of tools for storing and analysing information – Ian Hacking (1990), following Crombie (1961), speaks of six. The encyclopaedic form, which emerged in the late eighteenth century, might be useful when one is only dealing with a constrained body of data. However, with the information explosion that followed from the industrial revolution, new tools were developed. Two of these – statistics and genetic classifications – spread widely across social and natural science in the nineteenth century. Hacking has shown how statistical techniques (note that the root of the word 'statistics' is 'state') travelled between astronomy and social science and back again; until now courses in most sciences are inconceivable without a training in statistics. Patrick Tort (1989) has traced the spread of genetic classification systems (systems where classification is based on the origin and

history of the thing being classified) across linguistics, mineralogy, biology and other sciences. With such a system, a single classification and a rule for development can be used to compress data otherwise being held in a variety of different sources.

Central to these new work practices was the development of new types of spatial and temporal packaging of information. Indeed both the statistical form and genetic classifications are, in the form primarily of Darwin's evolutionary theory which combined both and the second law of thermodynamics, associated with major changes in world view in the nineteenth century about the nature of time. They provided an arrow to time together with a new way of storing data by offering the historicization of the biological world and of the universe as a whole. Proponents of genetic classifications offered new spatial packaging too by treating time as another spatial dimension. They argued the equivalence between going out in space and back in time in sociology, biology and astronomy. Statistical analysts deal in aggregates distributed in space (gases, peoples) that had previously been inaccessible to scientific reasoning.

In each of the sciences where these two new forms appeared, they seemed to be breakthroughs particular to that science: at least that is the way in which later histories came to be rewritten. Over the past 25 years, however, there has grown up a vast body of work suggesting that our social and natural apperceptions of time and space have changed in a unified fashion since the industrial revolution. The earliest work pointing in this direction in Britain was E. P. Thompson's pathbreaking analysis of time, work discipline and capitalism (Thompson 1967). Since then, historians of science and technology looking at the theory of evolution (Young 1973), at geology (Bowker 1989) and at the machinery question (Berg 1980) have explored the relationship between the immediate organization of social time and space and the time and space of the theory produced in the nineteenth century. Dupuy (1982) and others have extended this to an analysis of the new social space that network technologies are creating; Traweek (1988) has looked at the organization of social and natural time in high-energy physics laboratories today. Barbara Adam's recent *Time and Social Theory* (1990) magisterially surveys this complex field.

Thus I will be arguing in the case studies below, that new manipulations of space and time mediating work practices were responsible, first for permitting the statements of information mythology that everything is information, and second, for making those statements true. Historiographically, the move that I am describing

here attaches to a revisionist tendency operating independently within many diffferent strands of current historical scholarship. These strands can be united if they are seen as each in their own way contributing to a general 'infrastructural inversion'.

The best-known example is that of the relationship between sanitation and medical science in the nineteenth century. It used to be assumed that advances in medical science – universal vaccination, new treatments, etc. – caused the rise in life expectancy during the nineteenth century. Then came the infrastructural inversion. By this view it was changes in living conditions – in particular improved diet and sewage – that led to the rise. For the revisionists, the interesting historical question was how medical science came to take all the glory. This kind of inversion has also been operated within the history of technology. Thus it has been argued that all the business advantages of being able to process huge amounts of data should not be traced back in time to the computer (which its advocates have claimed to be the source of this new ability), but to changes in bureaucratic organization which in turn made the computer possible. The work of Campbell-Kelly (see Chapter 3), Beniger (1986) and Chandler (1977) points in this direction.

This suggests the need for a general form of investigation, as follows. Take a claim that has been made by advocates of a particular piece of science/technology, then look at the infrastructural changes that preceded or accompanied the effects claimed and see if they are sufficient to explain those effects – then ask how the initial claim came a posteriori to be seen as reasonable.

This question's relevance for this chapter is that it gives a way to comprehend the movement whereby a lot of people have come to the belief that 'information' is simultaneously a fact about economic life and the daily operation of business and a fact about the material world or about humanity. This, or some similar analytic move, is unavoidable. If we were to just accept the hyperbole, then we would get an inexplicable (or as in Beniger's case a highly deterministic, politically fraught) conjunction between the nature of the universe and current economic structures. If we were to just dismiss the hyperbole, then we would fail to explain an extremely widespread feature of writing about information. With the honourable exception of the work of many contributors to this volume,[2] for too long in the historiography of science and technology, organization work has been the excluded middle in this equation. In the case of information, organizational work is central.

There will not, within the confines of this chapter, be room enough

to produce a full-blown demonstration of the operation of infrastructural inversion and its relationship to information mythology. Rather, I will take two disparate cases – one very general and the other much more fine-grained – and show how the same inversion can explain the conjunction of statements about the nature of the world and innovations in business practice.

BABBAGE – THE NARRATIVE CONSTRUCTION OF THE INFORMATION REVOLUTION

Charles Babbage is a great icon for the information age. He worked for many years on a difference engine (recently incarnated at the Science Museum in London) and on an analytical engine whose logical structure prefigured the modern computer. He was intensely interested in industrial Britain, writing a classic text describing his researches entitled: *On the Economy of Machinery and Manufactures* (Babbage 1832). He also composed an explicit myth for the information age: *The Ninth Bridgewater Treatise; A Fragment* (Babbage 1837). In this work, Babbage made his own (uninvited) contribution to a series of tracts of natural theology produced by leading scientists during the 1830s. Babbage thought that his difference engine and his own reading of physics was much more powerful than that of William Whewell (1833), who had been charged with the latter subject. We will now look at the narrative form of this text, showing the operation of the infrastructural inversion by means of the role of information storage in shaping time.

For Babbage, the storing of knowledge plays a key part in the story of humanity – and that link is forged technologically. Until the invention of printing, he wrote: 'the mass of mankind were in many respects almost the creatures of instinct' (Babbage 1837: 51). Now, the great are encouraged to write, knowing that: 'they may accelerate the approaching dawn of that day which shall pour a flood of light over the darkened intellects of their thankless countrymen' (Babbage 1837: 57), seeking: 'that higher homage, alike independent of space and time, which their memory shall for ever receive from the good and the gifted of all countries and all ages' (Babbage 1837: 55–6). Since printing, the rate of progress of humanity has 'vastly accelerated'; over the past three or four centuries 'man, considered as a species, has commenced the development of his intellectual faculties' (Babbage 1837: 55–6). Already a key feature of the information revolution given at the beginning of this chapter – the revolution and the definition of humanity in the Simon reference – is linked to a

piece of technology via its infrastructural operation on the shaping of time and space.

But Babbage goes much further. Just as no human information has been destroyed since the invention of printing (so creating humanity), so has no information ever been lost in nature. When we speak, he wrote, the

> waves of air thus raised, perambulate the earth and ocean's surface, and in less than twenty hours every atom of its atmosphere takes up the altered movement due to that infinitesimal portion of the primitive motion which has been conveyed to it through countless channels, and which must continue to influence its path throughout its future existence.
>
> (Babbage 1837: 110)

Put simply: '[t]he air itself is one vast library' – 'no motion is ever obliterated'. In a bizarre image, he claims that within every murderer there is a record of the crime – 'some movement derived from that very muscular effort, by which the crime itself was perpetrated' (Babbage 1837: 113, 117). This position, as his friend Herschel protested, was contrary to the physics that he knew. It is matched by a position opposed to his close friend Lyell's geology. For Lyell (1830–3), the earth was a notoriously bad record keeper (hence the appearance of discontinuity). Babbage wrote of geological strata:

> every shower that falls, every change of temperature that occurs, and every wind that blows, leaves on the vegetable world the traces of its passage; slight, indeed and imperceptible perhaps to us, but not the less permanently recorded in the depths of those woody fabrics.
>
> (Babbage 1837: 228)

Thus we have the definition of humanity with the development of libraries, and the air itself as one vast library with the development of science – a development permitted by the development of libraries. This 'bootstrapping' was noted by Babbage well before Eisenstein (1979), who links the development of the printing press to the organization of knowledge into linear, absolute time (since books – unlike, say, yantras – present facts in a linear sequence).

This is one time trope in Babbage's work. It is complemented by a second, one concentrated not on time past but time future, not on memory and printing but on the future, the calculating engine and the industrial revolution. He argues that all changes that occur and are

going to occur are: 'the inevitable consequences of some more comprehensive law impressed on matter at the dawn of its existence' (Babbage 1837: 49). He revels in a complete Laplacian determinism, whereby if we knew the original position of every atom in the atmosphere: 'supposing the interference . . . of no new causes, the circumstances of the future history of the whole of the earth's atmosphere would be distinctly seen, and might be absolutely predicted for any even the remotest point of time' (Babbage 1837: 112). As the printing press marked the capture of the past, so did the calculating engine mark the determination of the future. He gives an extended analogy whereby the calculating engine could have a single deviation written into its regular working – a deviation which would perhaps not be evident for 'myriads of ages', and would only occur once. This deviation would have all the appearance of a 'miracle', but would in fact be determined from the moment of the setting of the machine (Babbage 1837: 170).

In order for this determination to occur, he needs the regular working of the machine, the regular ordering of time. Thus he shows how even minute phase differences of tide in a spheroidal world with two great tides would have a large effect over hundreds of years (Babbage 1837: 220). He is in horror of these irregularities. In counterpoint to the past of the former trope, here the past seems to him full of noise and cacophony – irregularity. Thus a future punishment would be the connecting of the soul of a dead man to a 'very sensitive bodily organ of hearing'. Suddenly: 'all the accumulated words pronounced from the creation of mankind will fall at once upon that ear'. This repeated image of past noise is complemented by the dreary observation that for most: 'oblivion would be the greatest boon' and a look forward into a well-ordered future:

> if that Being who assigned to us those faculties, should turn their application from survey of the past, to inquiry into the present and to the search into the future, the most enduring happiness will arise from the most inexhaustible source.
>
> (Babbage 1837: 148–50)

Yet how are we going to get an ordered future, that consummation most devoutly to be desired? We need to look to machines and manufactures: to the infrastructural task of ordering work processes into regular temporal units. He writes that:

> The advantages which are derived from machinery and manufactures seem to arise principally from three sources: *The addition*

> *which they make to human power. – The economy they produce of human time. – The conversion of substance apparently common and worthless into valuable products.*
>
> (Babbage 1832: 3)

It is this second – the economy of human time – that is the key:

> So extensive and important is this effect, that we might, if we were inclined to generalize, embrace almost all the arguments under this single head; but the elucidation of principles of less extent will contribute more readily to a knowledge of the subject.
>
> (Babbage 1832: 5)

People are wayward, they belong to the empire of noise. But machines can tame this, they provide a 'check . . . against the inattention, the idleness, or the knavery of human agents' (Babbage 1832: 39). Humanity is freed from the animal world by printing and from the empire of noise by machinery. This latter freedom is for Babbage directly attached to the principle of the division of labour:[3] a principle that in a famous image he ties in to the Coventry system of clock production (Babbage 1832: 52). This principle: 'can be applied with equal success to mental operations', ensuring 'the same economy of time' – thus proving that:

> the principles which ought to regulate the interior economy of a manufactory, are founded on principles of deeper root than may have been supposed, and are capable of being usefully employed in paving the road to some of the sublimest investigations of the human mind.
>
> (Babbage 1832; 153)

The principle of the division of labour and the development of machines acts to regularize social time in such a way as people will become regular and predictable and memory and noise will be destroyed. The calculating engine will be the symbol of this new deterministic universe.

This equation of division of labour with regular time and with the functioning of a deterministic universe was by no means peculiar to Babbage. Claude Lucien Bergery, who ran courses on elementary astronomy (Bergery 1832) and industrial economy (Bergery 1829) for the edification of workers at Metz makes exactly the same connection. He wrote that the principle of the division of labour was: 'really the base of the social state we have the good fortune to live in' (Bergery 1829, vol. 2: 105). It led to 'simple and periodic' tasks for

the workers, which allowed them to set up a 'rhythm' (ibid.: 105–6). He noted that: 'each person is capable of executing at least 5 movements a second, that there are 36,000 seconds in a 10-hour day and that consequently 180,000 movements are possible' (ibid.: 108). But these should be ordered movements. Addressing himself to manufacturers, he wrote that: 'your interests are better served by an ordinary but regular manufacturing process than by perfect, but unmethodical work' (Bergery 1829, vol. 3: 53). He shared with the workers of Metz his utopian vision, whereby through the division of labour, people were becoming rhythmic and periodic, noting that: 'the laws which preside over your honourable works are the same that rule the vast universe' (Bergery 1832: 70–1).[4] Bergery thus makes the same analytic moves as Babbage in the construction of his information mythology.

In this narrative construction of the information revolution, then, that revolution was shown to draw on a social time which was discovered to be the same as natural time. This 'discovery' was made possible because the manufactories had regulated people into periodic time, and because libraries had inscribed evanescent human social time into absolute time, where nothing was ever lost. Whether the manufactories or the libraries provided the link, it was an infrastructural technology that underwrote this buckling of social and natural time – and thus the epiphany of the information revolution. The story was told by Babbage and others as if the human race had now discovered an eternal truth. By operating an infrastructural inversion on this narrative construction we have seen how, rather, technological change was inscribed into stories about the nature of the universe.

SCHLUMBERGER – THE PRACTICAL CONSTRUCTION OF THE INFORMATION REVOLUTION

For the second case of infrastructural inversion and information mythology, we will move into the twentieth century and the post-industrial age to look at the operations of the Schlumberger company. Schlumberger was perhaps one of the first companies to earn its money by selling scientific information. From the late 1920s, Schlumberger engineers produced electrical 'logs' of the subsoil: readings of changes in resistivity of the different layers traversed during the drilling of an oil well. With these readings they could, so they claimed, produce more accurate mappings of the subsoil, and in particular of oil-bearing layers, than were available by other

means. After a period of initial scepticism, they succeeded so well that from the end of the 1930s up to the present, all oil wells being drilled get logged.

We do not for our purposes need many details about the process whereby they set up as an independent company specializing in logging and built up an effective monopoly in spite of the oil companies' attempts to attack them in the courts and by supporting rivals. One of the key features of this process was getting control both of the data they generated and of its interpretation. At one stage, the oil companies insisted on getting the logs that were generated before Schlumberger engineers had a chance to look at them. This was a triply dangerous move: it threatened to give the companies expertise in interpretation; to deny Schlumberger local knowledge about a particular field; and to prevent Schlumberger from carrying out experiments on the spot under the noses of the companies (without their being aware of the process) and thus developing their techniques. One manager grumbled about the 'disastrously unintelligent role' they were being forced to play (Schlumberger/Box USA 1934–1938, 8 March 1934). So there was a tussle for control of information flow, but both the oil companies and Schlumberger believed at the time (albeit to differing degrees) that what was at stake was a mapping of the real world.

In a later interview, one of the inventors of their successful techniques said:

> The log that you take essentially measures the invaded zone [the zone that has been invaded by the driller's mud]. Now maybe that means something, but after all if you really want to know whether there is water or oil with your resistivity measurements we now know that there is not so much difference between a petrol layer and a water one, unless you want to look behind the invaded zone – which neither of these measurements did.
>
> (Schlumberger/Box H. G. Doll)

This frank appraisal of Schlumberger's methods poses two questions: first, how did they manage to sell measurements that did not work; and second, how did they develop the measurements so that they managed to survive (and in fact become the accurate measurements that they are today)?

A full answer to the first question is beyond the scope of this chapter. Briefly, what Schlumberger did was to manage information flows in two ways. They gathered information of any sort they could get hold of (from local reports, to observing rival companies, to

measuring temperature, magnetic, radiation and many other sorts of variations to see if correlations could be found). By their very presence on the oil fields, they were able to pick up local, particular information which they could repackage through electrical logs and interpret as global, scientific information. Second, they were able to take advantage of the organization of the oil fields. Often rival companies would be drilling the same field. These companies would not share information with each other, but would frequently be in the position of not being able to do without shared information. Schlumberger acted as an 'information broker' in these cases. Forbidden by their statutes from owning any part of an oil field, they were trusted by the companies, who benefited from their shared local information – again repackaged as abstract, global information.

This process is interesting enough in itself, showing as it does how the 'mythology' of producing scientific knowledge about the world helped Schlumberger do their real work of managing local-information flows. More important here is an answer to the second question: how did Schlumberger's actions become an accurate description of the world? It is in answering this question that we will find most clearly the infrastructural inversion that sees the work practices of the oil companies and Schlumberger together being inscribed in the world, through the manipulation of local space and time in such a way that objective 'information' could be achieved. We will see that the process of rendering Schlumberger's results generalizable was integrally one of operating infrastructurally (changing the way in which the social and natural world around the oil well was configured) and operating theoretically (producing descriptions of that social and natural world). Thus statements describing an economic practice (the organization of information and material flow) also became statements describing the real world. And thus a train of socio-logic was set in motion that made information mythology possible.

We will look briefly at how a new space and time were created socially and applied in Schlumberger's scientific work. A clear case is the unexploited territory of northern Venezuela: jungle country through which prospectors had to fight their way with machetes in search of their Shangri-La. Yet after cutting through the undergrowth, geologists and geophysicists could send back very well structured information about their discoveries. Here is an account from a 1929 geology of Venezuela and Trinidad that combines key spatial and temporal features of this new kind of information packet:

Rio Tarra Field

> *Location and accessibility* – State of Zulia, district of Colon. Accessible by shallow-draft boats via Lake Maracaibo; Rio Catatumbo; and Rio Tarra to La Poloma. Narrow gauge railway to camp.
> *Date of discovery* – Toldo No. 1 of the Colon Development Company entered production August 27, 1916.
> *Producing horizons* – Fifty feet of sandy shale in middle of First Coal horizon carry light oil. . . .
> *Structure* – Rio Tarra anticline is asymmetrical throughout entire length; has locally vertical and slightly overturned east flank; and more gently inclined west flank. . . .
> *Character of oil* – Asphaltic oil, varying from 23° Bè to 32 Bè. Higher gravity oil obtained from Tabla sands at base of Third Coal horizon of Eocene age.
> *Production* – Production has been consumed in drilling operations. Tankage being erected. No facilities for exportation of oil. About 25,000 barrels production to December, 1925.
> (Liddle 1929: 67)

There are references here to three kinds of map of the oil domain: a transport map, a map of geological structure and a map of subsurface structure. There are three kinds of date: the era of the formation of the oil, its date of discovery and the statistical year 1925.

These new kinds of space and time were made possible literally and figuratively by a great deal of infrastructural and organizational work. As to social and natural space, the first and most obvious point is the physical presence of the network – nodes of high energy connected by thin strands in the form of roads and pipelines. The old state was often a mass of impenetrable jungle: the network rendered it, at key points, visible and accessible to the oil companies. Within this network space, the companies could produce local order in the disordered space of the old state. Measurements down an oil well displayed ever greater degrees of accuracy, and mileposts lining the roadside provided a new set of local reference points that allowed the accretion of more local knowledge.

This procedure has been described by Bruno Latour as the production of 'immutable mobiles' within network space (Latour 1987). These immutable mobiles can be combined, collated, compared and shuffled. They allow a redistribution of power from the local resident to those in the centres of calculation who deploy them. The space within which these new measurements/markers (the oil

well and the asphalted road) operated were equally ordered and universal. In whatever country they occurred, these pockets of uniform space allowed a deeper, more penetrating knowledge of the old state.

The networks of the oil companies also created a new social and natural time indifferent to traditional Venezuelan times. Organizationally, this involved the oil wells moving into 24-hour production (denying cyclical time), recording dates for accounting, organizational and scientific purposes. It seems likely that the first recorded historical date at Rio Tarra is 27 August 1916. From then on, one could give a second-by-second description of measurements taken within some given well, a year-by-year description of its production and (going back some millennia) an account of the origins of the formations that yielded the oil. The oil companies through their networks interfered minimally with Venezuela, owning no property therein and operating on a totally different time scale.

It was only within the context of this infrastructural work of organizing space and time that an effective laboratory space could be created within which Schlumberger could produce their measurements. It is for this reason that one needs to operate an infrastructural inversion in order to understand Schlumberger's creation of objective information. From within the space and time that the oil companies created, it was quite possible to talk about pure information being produced and processed. An analogy to the case of medical science and sanitation applies here. It is scientifically and socially prohibitively difficult to do the scientific work of classifying children's diseases, for example, until you have done the more basic work of clearing out the myriad causes of infant diarrhoea by improving the water supply. It is scientifically difficult because there is too much 'noise' otherwise: too many causes of death funnel into the general rubric 'infant diarrhoea', with children dying before their specific conditions present themselves. It is socially difficult because the necessary medical specialities can only evolve slowly without there being some perceived benefit from their exercise – you won't get funding until the classification is possible. Similarly, you could not measure down oil wells without first creating a network, negotiating information flow and so on. This bootstrapping operation was made possible by the development of network space and time.

Thus the effort required to make the information company Schlumberger a success was the organizational work of creating a convergence of social and natural space and time. This convergence was not something that existed before the oil companies produced

their networks: it came into existence with those networks. Within this new space and time, information could be at once an economic commodity and a fact about the world – exactly the conditions that we sought in order to explain the roots of information mythology.

CONCLUSION: THE MYTHOLOGY OF INFORMATION

We have seen in a narrative and in a practical setting how information could take on the dual quality of being an economic fact and a fact about the world. In both cases, the act of making information such a key variable tied directly into operations on social and natural space and time: for Babbage the regularization of time and the distribution of tasks, for Schlumberger operation within the network time and space of the oil companies. In both cases, the mythological operation succeeded because of the infrastructural work: for Babbage the development of the printing press, of computing tools and other machinery and the imposition of the principle of the division of labour, for Schlumberger the range of road-building, mapping and drilling activities that made it possible to turn the oil field into a laboratory.

When we operate this infrastructural inversion, we can see that there is a clear link between the nature of the universe and the way to run a business. Information mythology is not an epiphenomenon generated out of thin, hot air: it describes an integral part of the economic process of ordering social and natural space and time so that 'objective' information can circulate freely. The global statement that everything is information is not a preordained fact about the world, it becomes a fact as and when we make it so. Schlumberger and Babbage, Simon and Beniger package up the world for us and make it deterministic. The unpacking of their information mythology makes the world and its information historical again – and richer for it.

NOTES

1 I am using the word 'mythology' here as a reference to the anthropological treatment of mythology by structuralist anthropologists Georges Dumézil (1968) and Claude Lévi-Strauss (1964): viz. as less a series of particular stories than as a unified way of patterning stories, this unified patterning being a reflection of the social construction of time and space in a given society.

2 Most notably here the work of Alain Desrosières (for example, Chapter 8, this volume), whose work on job classifications provides a superb empirical, organizational base for analysis of the state.

3 Berg (1980) has a good discussion of Babbage and the division of labour.
4 Cf. here Richard R. John (see Chapter 5), whose deconstruction of the rhetoric of speed in favour of the reality of regularity provides a fine example of periodic time being underwritten by infrastructural change.

BIBLIOGRAPHY

Archival sources

Schlumberger. The archives are held at the Ecole des Mines, 62 Boul. St. Michel, Paris. They are filed by box, folder, and document numbers. The following material has been cited in the text:
Schlumberger/ Box H. G. Doll, Folder Interviews Doll.
Schlumberger/ Box USA 1934–1938, Folder 1934, letter of 8/3/34.

References

Adam, B. (1990) *Time and Social Theory*, Philadelphia: Temple University Press.
Babbage, C. (1832) *On the Economy of Machinery and Manufactures*, London: C. Knight.
—— (1837) *The Ninth Bridgewater Treatise; a Fragment*, London: C. Knight.
Beniger, J. (1986) *The Control Revolution: Technological and Economic Origins of the Information Society*, Cambridge, MA: Harvard University Press.
Berg, M. (1980) *The Machinery Question and the Making of Political Economy, 1815–1848*, Cambridge: Cambridge University Press.
Bergery, C.-L. (1829) *Economie industrielle; t. 1 – économie de l'Ouvrier; t. 2 – économie du fabricant, partie 1; t. 3 – économie du fabricant, partie 2*, Metz: Thiel.
—— (1832) *Astronomie elémentaire; ou description géométrique de l'univers, faite aux ouvriers messins*, Metz.
Bowker, G. (1989) 'Les origines de l'uniformitarisme de Lyell: pour une nouvelle géologie', in M. Serres (ed.), *Eléments de l'histoire des sciences*, Paris: Bordas.
Chandler, A. D., Jr (1977) *The Visible Hand: The Managerial Revolution in American Business*, Cambridge, MA: Belknap Press of University of Harvard Press.
Crombie, A. C. (1961) *Augustine to Galileo*, Cambridge, MA: Harvard University Press.
Dumézil, G. (1968) *Mythe et épopée*, Paris: Gallimard.
Dupuy, J.-P. (1982) *Ordres et désordres: enquête sur un nouveau paradigme*, Paris: Seuil.
Eisenstein, E. (1979) *The Printing Press as an Agent of Change: Communication and Cultural Transformation in Early Modern Europe*, Cambridge: Cambridge University Press.
Forester, T. (1980) *The Microelecronics Revolution: The Complete Guide to*

the New Technology and its Impact on Society, Cambridge, MA: MIT Press.
Hacking, I. (1990) *The Taming of Chance*, Cambridge: Cambridge University Press.
Kling, R. (1991) 'Computerization and social transformation', *Science, Technology and Human Values* 16,3: 342–67.
Latour, B. (1987) *Science in Action: How to Follow Scientists and Engineers Through Society*, Milton Keynes: Open University Press.
Lévi-Strauss, C. (1964) *Le Cru et le cuit*, Paris: Plon.
Liddle, R. A. (1929) *The Geology of Venezuela and Trinidad*, Fort Worth, TX: MacGowan.
Lyell, C. (1830–3) *Principles of Geology*, 3 vols., London: J. Murray.
Oxford Dictionary of Computing (1983), Oxford: Oxford University Press.
Thompson, E. P. (1967) 'Time, work discipline and industrial capitalism', *Past and Present* 38: 56–97.
Tort, P. (1989) *La Raison classificatoire: quinze études*, Paris: Aubier.
Traweek, S. (1988) *Beamtimes and Lifetimes: The World of High-Energy Physicists*, Cambridge, MA: Harvard University Press.
Whewell, W. (1833) *Astronomy and General Physics Considered with Reference to Natural Theology*, London: Whittingham.
Wiener, N. (1948) *Cybernetics; or, Control and Communication in the Animal and the Machine*, New York: Wiley.
Yates, J. (1989) *Control through Communication: The Rise of System in American Management*, Baltimore: Johns Hopkins University Press.
Young, R. (1973) 'The historiographic and ideological contexts of the nineteenth-century debate on man's place in nature', in M. Teich and R. Young (eds), *Changing Perspectives in the History of Science*, London: Heinemann.

Index